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THE JOURNAL OF PERIODONTOLOGY is published to serve as the professional journal of periodontology; to keep dentists in touch with research being carried on in this field and related sciences; to stimulate greater interest in the supporting tissues of the teeth and their relation to oral and general health.

The Journal is the official organ of the American Academy of Periodontology and will contain, therefore, papers of scientific and clinical interest which are presented at the annual meetings of that society, as well as articles submitted direct to the Editor. Obviously opinions expressed do not necessarily represent those of the Editor or the American Academy of Periodontology.

1960 Annual Meeting

October 13, 14, 15, 1960

Mirimar Hotel, Santa Monica, Calif.

This is a special issue of the
Journal of Periodontology designed to honor
Dr. Balint Orban
The regular October issue will be published as usual

Balint Orban

March 24, 1899—July 1, 1960

Nearly every field of endeavor has been marked by periods of unusual progress and are designated as eras. These eras frequently are due to the influence of one man or a group of men associated with a dominant personality who influences the thinking and action of the group. Osler strongly influenced the practice of internal medicine, Lister the practice of surgery, and Koch the field of bacteriology. Each of these individuals

established a new plateau from which those who followed could ascend to new heights. Balint Orban will hold the same high place in the field of periodontology that Osler holds in medicine.

For the past twenty or more years Orban has been a strong influence for an increasing interest in periodontia. Throughout his very active career, Orban has been a dynamic and tireless investigator and writer in periodontal histology and pathology. He also had the unusual ability of making this subject interesting to practitioners in demonstrating its relation to clinical practice. Because of his dynamic personality he made everyone feel that histopathology was of the utmost importance in periodontal practice, and he created such an interest that everyone was convinced of its importance. His witty repartee, his love of an argument (in which he rarely came off second best), and his positive attitude attracted many to his lectures. He was an excellent orator and showman with a most convincing delivery of his wealth of information. This ability permitted him to present a subject usually thought to be somewhat "dry" as one of fascinating interest and importance. His enthusiasm for histopathology was so infectious that he attracted many to participate in study groups and seminars and thus learn by experience. His positiveness, both in his lectures and in his writings, stimulated many to take issue with him and then work to prove him wrong. I think this was in part intentional and a part of his philosophy of teaching as was indicated by his remarks in a conversation about his old mentor Gottlieb. Orban said of Gottlieb, "One of his major accomplishments was his tendency to write spontaneously without exhaustive investigation and draw conclusions which could be questioned, thereby encouraging those who doubted to work to prove him wrong." I think Orban intentionally employed this technique of his old teacher to stimulate others to seek the truth along with him.

Balint was a tireless worker with a very active inquiring mind and an unusual ability for organization. He always had numerous projects in progress, papers in the writing, and programs to participate in, while at the same time carrying on an active practice. His energy was unlimited and his enthusiasm unbounded. He was at the same time generous and kindly. He was never too busy to lend a helping hand to a sincere young man who was trying to make a start in the field of histopathology. He would take them in his laboratory and teach them technique, provide them with material and assist in the solution of their problems. He was so embued with the importance of histopathology in periodontia that he would never overlook an opportunity to further such knowledge.

Because of the work of Orban and his associates such as Weinmann and Sicher, a biological background was provided for the understanding and treatment of pediodontal disease. The knowledge of histopathology which Orban provided and the interest which he created in this knowledge has been a milestone in periodontology. Instead of a few, many became interested in periodontal disease; the treatment, because of the establishment of a biological background, became more rational and successful, and a greater demand for treatment was established.

The influence of Balint Orban established the histopathologic era of periodontology, and during his lifetime the dynamic, restless, aggressive, sometimes arrogant, man with the persuasive delivery and beguiling chuckle has in some way touched the career of all who are interested in the field of periodontology. No greater memorial can be established in his honor than that which he established for himself by his work and through his writings.

Good hunting, Balint.

Donald Kerr, D.D.S.

With the death of Dr. Balint Orban, Dentistry has lost a dynamic leader whose activity will leave lasting marks in many fields of dental science. It gives me great satisfaction to be able to write these lines in memory of my friend of many years, Balint Orban.

He was born in May 1899 in Temeszvar, Hungary, earned his M.D. in 1922 in Budapest and in 1930 his M.D. in Vienna.

During the first few years following World War One a group of research minded Dentists gathered in Vienna under the leadership of Dr. B. Gottlieb and tried to find a new biological approach to many dental problems. Histopathology and animal experiments were some of the tools.

Orban's contributions were soon outstanding. By *1926* an impressive collection of histopathologic slides and photomicrographs were ready to be shown at the meeting of the *Federation Dentaire International* in Philadelphia. This exhibit caused great interest and Dr. Logan of Loyola University offered Orban a position as Professor of Oral Pathology. Orban accepted for a limited time and stayed at Loyola University from 1927 until 1929. During this period he published a book on Dental Histology and many articles on oral pathology. In 1929 Orban returned to Vienna. Back in Vienna he continued an intensive research activity. A great number of scientific papers, ranging from embryology to minute studies of periodontal tissues and the pulp were written.

Following an increasing longing for the United States he moved in 1937 to Chicago and received his D.D.S. at Northwestern University in 1938. This enabled him to carry on a limited private practice.

Orban developed into an excellent clear and forceful speaker and his lectures, clinics and seminars were overcrowded. His opinion had authority and his counsel was frequently asked for and freely given. He was chairman of the research commission of the F.D.I. from 1936 to 1952 and received the Miller prize of the F.D.I. in 1952. He published about 150 scientific papers and wrote and participated on a number of widely used textbooks.

His untimely death is deeply mourned by his many friends and pupils.

George Stein, M.D., D.M.D.

It is with heavy heart that I write about the loss of a very dear and close friend. A loss also of a devoted teacher and scientist to the dental profession. Dr. Balint Orban died suddenly on July 1, 1960, as I was speaking to his wife on the telephone from the hospital.

Too few men have contributed to their life's work as Balint Orban has done. His devotion to teaching and research should be an inspiration to those who have yet to follow the footsteps of this great man and teacher.

His scientific works have helped to lay the foundations of the present modern concept in the teaching and practice of periodontics. His gift of inspiration to so many who knew and studied with him was a stimulus in the search for truth on a scientific basis. Orban's influence on a personal level in seminars and lectures caused many men to have a better understanding and devotion to their profession and has helped to disseminate his philosophy on a world-wide basis.

I have been fortunate indeed to know well on a personal and professional level his devotion to periodontics; the interest, and love he stimulated in his patients, the meticulous details that went into the preparations of his scientific papers and books, the hours of patience to create a perfect histologic section and photo-micrographs for publication, the detailed plans for future scientific studies, his enthusiasm in preparation for his seminars held each year, and the love and devotion he inspired in many men he influenced by his enthusiasm and understanding.

Balint Orban as a scientist concentrated his energy on the problems of histology and pathology. Few know that he held in addition to a dental degree, two medical degrees. The second medical degree awarded to him in 1930 by Vienna University for his outstanding scientific achievements and research.

His fantastic energy and interest in research began under the influence of Bernard Gottlieb in Vienna in 1923. This inspiration triggered a lifetime of research and a continuous flow of scientific papers. The first of these was *Ueber die Beziehuger von Schildruse and Miz zur Blutbildung, Archiv. f. exper. Path. u Pahr Bd. 97-1923.*

His research activity centered at this time in Vienna in the laboratory of Gottlieb. During this period too is when his association and friendship began with Dr. Harry Sicher and the late Dr. Peter Weinmann.

These early papers were devoted to histology. However, as early as 1924 a paper of his was published on periodontal disease, this is understandable, as one of the objectives of Gottlieb's group was a better knowledge of periodontal diseases. These early efforts produced classic work on tooth development, the dental pulp, and a better understanding of dentogenises. It was also at this time Orban became interested in the classification of the oral mucosa. Gottlieb's discovery of the epithelial attachment led to widespread controversy. This in turn stimulated Orban to further work that proved the challenges to the epithelial attachment to be untrue.

Additional papers on histology were inspired during the period when he organized the Foundation for Dental Research at Loyola University Dental School in Chicago. Later with Weinmann the histopathology of periodontosis was studied, and other, including gingivitis in pregnancy with Maier and gingival changes in diabetes and several papers with the late Harold Ray.

It was because of his research achievements that he received the Miller Award in London in 1952. Thru his efforts with Ritchey and Downs the Colorado Dental Foundation was organized in Colorado Springs in the 1940's.

Many papers pertaining to histopathology of the supporting structures were published and a series of experiments and papers on trauma written and correlated with Orban and Gottlieb's early trauma experiments on dogs. This foundation helped organize the Histopathology Study Club and its seminars. Orban's teaching stimulated much interest and was directly responsible for a number of men to study and take up teaching and the practice of periodontics. It was here, too, the seed began to germinate with such papers as *Gingivoses* with Grupe and Foss, *Leukoplakia* with Kollar, Finley, Nabers and Ritchey, *Psorias* with Grayshow and others with Engle, Ray, Maier, Wentz, Bhatia and Bhaskar that resulted in the book *The Atlas of Clinical Pathology of the Oral Mucous Membrane.*

This man in his short life span wrote and published almost two hundred scientific papers and two other books: "Periodontics" and "Oral Histology and Embryology." His untimely demise interrupted the compilation of new editions of the aforementioned

books along with papers on current research.

Dr. Orban and I had just finished a series of studies on the supporting tissues of the teeth of monkeys. These experiments were a series on overfunction, chemical stimulation of osteoblasts and tooth depression.

Balint Orban's life and contributions to his profession may be summed up in the words of another great teacher, close friend and scientist, Dr. Harry Sicher:

> "Orban worked with the energy and zeal of a man who knew he would die tomorrow and planned for the future as if he would live forever."

Such a man was Balint Orban, his last writing immediately before his death was the completion of case histories and material for the Histopathology Study Club for the month of December 1960.

His work will live not only in his papers, research and books, but also in the lives of those he enriched so much. It is on this limitless horizon that progress in research and teaching will continue in his chosen profession to which he had contributed so much through his scientific curiosity, enthusiasm and deep understanding.

John A. Kollar, Jr., D.D.S.

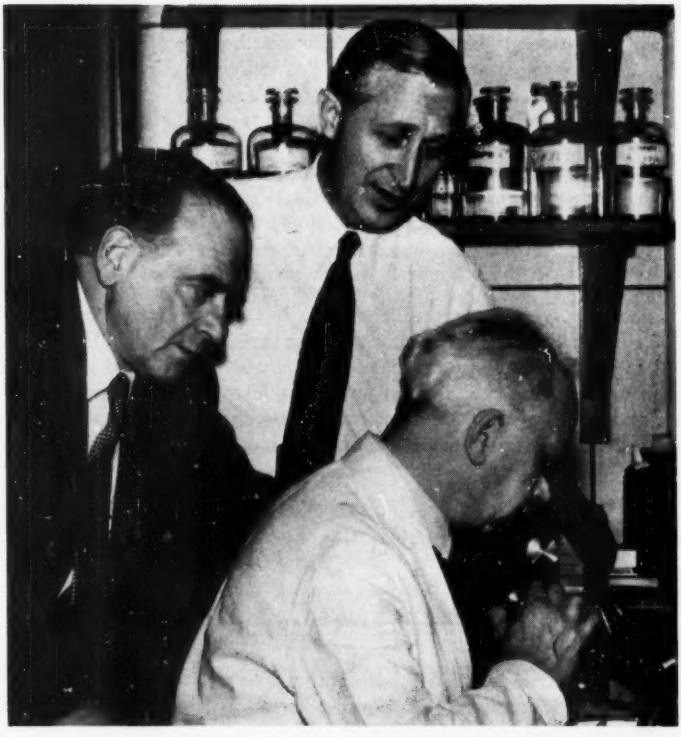
We have lost a great periodontist, a great scientist, a great man. Balint Orban's chief contributions have been in the application of biological principles in periodontology. His greatest scientific accomplishments were in the investigation of the epithelial attachment (attached epithelial cuff), of periodontosis, and of the tissue changes in occlusal traumatism. Beyond this fundamental work, there was hardly a phase in the field of periodontology that was not influenced and advanced by the genius and the efforts of Balint Orban. He contributed also greatly to our knowledge in oral histology and embryology, clinical and microscopic oral pathology, and endodontics.

It has been my privilege to have known Balint Orban since 1932, when I first listened to him as a student and later assisted him in clinical presentations at the University of Vienna Dental School. He has been an understanding, wise and friendly mentor, and has been forming and stimulating many, many students, young, and old, in directing them to seek the answers to the "Know-Why" of Periodontology. He realized that with the "Know-Why" conquered, the "Know-How" would follow almost by itself.

The loss of Balint Orban coming so shortly after Peter Weinmann produces a gaping void in our field, not least perhaps because these two men were main spokesmen for the "Vienna School."

The sudden death of Balint Orban leaves me and others, whom he honored by calling them friends, shocked, stunned, and in deep sorrow. We shall never forget him!

Frank G. Everett, D.D.S.



Dr. Orban with his two colleagues, Dr. Harry Sicher, and Dr. Joseph P. Weinman who died May 15, 1960.

(Photograph from Daniel A. Grant.)

The recent loss of our friend Dr. Balint Orban will forever leave a void in many lives. The following represents thoughts that pass through the minds of those that loved and respected him.

Balint Orban was professional father and personal friend to those who sought his counsel and knowledge. He was as proud of his students' accomplishments as if they were his own and continually worked in their behalf. He used his writings, seminars, and study clubs as instruments for the advancement of dentistry. Balint Orban inspired and changed lives and is surely the highest example of Paul's epistle to the Ephesians when Paul said: "I therefore, . . . beseech you that ye walk worthy of the vocation wherewith ye are called."

I shall forever be in his debt, and in many of us his friendship and inspiration will live into eternity. *John M. Nabers, D.D.S.*

Dr. Orban was a Hungarian by birth and both a physician and a dentist by training. He was deeply interested in biology and was an excellent research scientist. His interest in periodontal tissues and their diseases extends back to more than a quarter of a century, and of the specialty of periodontia he was a founder and a leader. He received many awards and published many papers; his travels and his teaching extended literally over the world, and men who trained under him practice today in Chicago, New York, London, Oslo, Paris, Budapest, New Delhi, Djkarta, Sidney, Seattle and many places in between. He wrote three major texts in the English language and these are classics in their field. Dr. Orban had a unique quality of integrating basic sciences to clinical problems and because of this, he contributed much to periodontology and to dentistry.

He was a very successful and a very well known man. But it was his humanity which, in spite of all other achievements, endeared him to his students and colleagues. He was friendly, thoughtful and cordial to deans and undergraduates alike. He was warm, encouraging, and a source of inspiration to his students. He let many of them share his fame, in fact, he planned things that way. His loss is a loss for dentistry and for periodontology, but perhaps it is greatest for those young men who would have learned from him in the future, and worked with him and attempted to model their lives after his own.

Joseph L. Bernier, Major General, D.C.
Assistant Surgeon General
and Chief of the Dental Corps

Dr. Orban had the ability to fire with enthusiasm and to inspire those with whom he came in contact. The greatest single thing he taught his students was to reason, to think for themselves. He taught by precept, by praise and above all, by example. He was always eager to help anyone who had the desire to learn.

He was a tireless researcher. He had patience and perseverance. Above all things he despised hypocrisy in research. He would not tolerate a fallacious theory. Tirelessly, he sought after the truth.

Dr. Orban excelled as a clinician, as a researcher and as a teacher. He was a beloved and faithful friend. I am thankful that I had the opportunity to know this great man.

Duncan Blades, D.D.S.

A beloved friend has passed from the scene. He will be missed by many. This was no ordinary man, his life defies any conventional eulogy. Where he was born, where he attended school seem unimportant.

Balint Orban is not dead—his spirit lives on. It is here today. Many of us can hear the laugh and remember the witty stories. The undying spirit lives in a thousand places, for he was an intimate friend to countless numbers in and out of the dental profession. For most men, the deep friendship of only a few men is considered a blessing: for Balint Orban there was almost no limit to the number of those whom he could call friend.

The caustic tongue is silent, but fragments of that undaunted spirit, the desire and

searching for the truth lives in every dental school in this land. The spirit lives on in the hearts of thousands of his friends and students.

Like all men, he had faults and frailties. This he knew better than anyone. Nothing would light up his eyes more than the prospect of a good verbal fight. Often did he repeat the phrase, "Always fight issues, never fight people."

He loved his profession as few men do. Had he made one last wish, it would be for us to push on; to disprove what he had stated if we could; to build a better tomorrow with understanding and truth among men. To those who sometimes feel a strange urge to do something more and better for his profession and fellow man, remember this: this urge may be the prodding of a dear friend they say has departed—it may be Balint Orban. *Charles W. Finley, D.D.S.*

The death of Balint Joseph Orban leaves a void in Dentistry and in the hearts of his many students and friends. I feel that Balint's friendship was one of the greatest blessings that God has given me and I shall always cherish the wonderful memories of this great scientist.

Very few ever contribute to a profession as much as he did. His name will live forever beside such names as Pierre Fauchard and G. V. Black. *Claude L. Nabers, D.D.S.*

With the passing away of Balint Orban, an era has passed, an era of accomplishment in the first great strides in the beginning of modern dental research.

To seek the truth and advance knowledge in the fundamentals in dental science are the objectives of the true research worker and to this end Balint Orban dedicated his life. His intense drive in research was a beacon of light for his co-workers and fellow colleagues and certainly his writings are forever recorded. Every future dental research worker will refer to his work.

Balint Orban was a teacher, author, research worker, and clinician. He had the rare facilities to be able to communicate with students and these were many. I am sure that in this respect his life was fulfilled with pride. An eminent author, he offered to the Dental Profession basic works in histology and periodontology. From his legacy the world has profited.

I was fortunate to know Balint Orban for a little over twenty years. I remember him as a gentleman and fine person.

To his family, I extend my regrets. *Henry W. Goldman*

Dr. Balint Orban will be greatly missed at Loyola. He has been on the staff of the Dental School almost continuously since 1928. He will also be missed by the entire dental profession because he give unstintingly of his time and talents as a speaker, clinician and writer.

Dr. Orban had become world famous as a periodontist. But, more than this, he was one of the finest histologists and pathologists of our time in dentistry. These two basic

science fields were his first love; they could explain, at least in part, his success as a periodontist.

As a young man Dr. Orban was brought to the Chicago College of Dental Surgery, now Loyola Dental School, by Dean W. H. G. Logan, from Dr. Bernard Gottlieb's laboratory in Vienna. His field then was histo-pathology and research. In fact, in 1928, he instituted the research department at the Chicago College and also taught histopathology.

He had a prodigious amount of energy, an inquiring mind and a wealth of scientific background. These are the attributes that made him a fine teacher and a very successful clinician. During his lifetime he was continually experimenting and searching for new methods and ideas in dentistry. Much of this work lives on after him in his books, in the printed words of his many papers, and in the minds of his hundreds of students.

So, Dr. Balint Orban has left as fine a heritage to dentistry as any one man could.

Wm. P. Schoen, D.D.S.

THE NORTHEASTERN SOCIETY OF PERIODONTISTS

The Fall Seminar of the Northeastern Society of Periodontists will be held on Friday, November 4, 1960 at the Park Sheraton Hotel, New York, N. Y.

The following essayists will participate: Irwin D. Mandel, D.D.S., Irving M. Sheppard, D.M.D., Harold G. Wolff, M.D., D. Walter Cohen, D.D.S., Frederick M. Chacker, D.D.S., Irving Glickman, D.M.D., Leonard Hirshfeld, D.D.S.

Further information may be obtained by contacting the secretary Dr. Irving Scopp, V.A. Hospital, First Avenue and East 24th Street, New York, N. Y.

Three-Dimensional Roentgenographic Interpretation in Periodontal Diagnosis

by THOMAS R. ORBAN, D.D.S., AND BALINT J. ORBAN, M.D., D.D.S., *Denver, Colorado*

IF roentgenograms are properly taken and processed, they give valuable information regarding the relation of alveolar bone to root surface. Proper interpretation of roentgenograms can be made only if the normal anatomical relations are well understood. In a paper by Ritchey and Orban,[1] the normal features that have to be taken into consideration in interpretation of roentgenograms of the interdental alveolar septa, have been discussed.

Recently, more emphasis has been given to the diagnosis and treatment of intra-alveolar bony craters and it has been admitted that roentgenographic interpretation is difficult.[2,3] It has been suggested that a hypodermic needle or probe be inserted into the questionable area to determine whether or not bone is present in a certain region. In fact, many times, the proper shape of bone can only be ascertained at the time of operation, when a flap is raised and bone is exposed.

The present study suggests that some difficulties can be overcome and clearer ideas of anatomic relations visualized, by roentgenograms taken at different angles, as is frequently done in locating a foreign body or an embedded tooth. By the use of such a technique, a three-dimensional view of certain regions can be constructed in the mind of the operator. John Prichard[2] has recognized the distortion of bony margins by roentgenograms and has emphasized correct projection. This is absolutely necessary in routine roentgenographic examination. The present study suggests a predetermined change in projection to create three-dimensional images.

Roentgenograms taken of a mandible (Fig. 1) clearly illustrate the point. An intra-alveolar bony defect exists on the distal surface of the first molar. A small piece of lead was laid on the vestibular alveolar crest and two pieces of lead placed on the oral alveolar crest. Three roentgenograms were taken with a short cone at various angles. Figure 2A was taken at a right angle to the tooth and film (0° angle). Figure 2B shows the same area taken at an angle of 25° from above (positive) and Figure 2C is the same region, taken at a 25° angle from below (negative). It is very obvious that the shadow of the vestibular alveolar bone with one lead marker, shows a greater shift in position than that of the oral alveolar bone (two lead markers).

Fig. 1. Vestibular view of mandible with an interdental intra-alveolar bony defect (A). Prominent oblique line (B) extending from the ramus of the mandible forward to the level of the second molar.

In projection A (0°), the vestibular and oral crests overlap. In projection B (plus 25°), the image of the vestibular lead marker shifts apically, whereas the images of the oral markers remain in about the same position. In projection C (minus 25°), the vestibular image of the lead marker travels coronally, whereas the oral images remain relatively stationary. The shift of the images of the lead markers is a parallactic shift produced by the various angles, located at various distances from the film, and can be easily illustrated in a diagram (Fig. 3). The vertical line indicates the position of the film on the oral side of the tooth. Figure 3A shows one

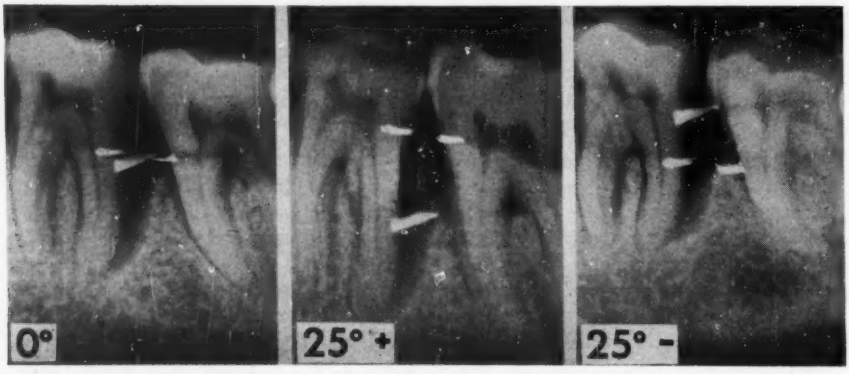


Fig. 2. Roentgenograms taken from the mandible shown in Fig. 1. One lead marker was placed on the vestibular alveolar margin and two markers placed on the oral alveolar margin. Observed the extensive apical shift of the single marker of the vestibular plate in a twenty-five degree positive angle projection and the coronal shift in a twenty-five degree negative angle projection. The oral markers remain relatively stationary.

lead marker placed on the vestibular alveolar crest and the shift of its image at various angles. Figure 3B shows lead markers placed on both the vestibular (one marker), and oral alveolar crests (two markers), and the extent of their shift with changing angulation.

The use of three roentgenograms (Fig. 2) allows the diagnosis of an alveolar defect localized to the distal surface of the first molar root, not extending either vestibularly or orally. It is a so-called three-walled intra-alveolar defect which, according to Prichard,[2] is most favorable for achievement of reattachment and regeneration of alveolar bone.

In a three-dimensional interpretation of roentgenograms, the understanding of anatomic landmarks is of great importance. The temporal crest of the ascending ramus of the oral surface of the mandible can produce a pronounced radiopaque shadow and so can the oblique line on the vestibular surface of the mandible (Fig. 1). The same is sometimes true for the mylohyoid line on the oral surface of the mandible. The possible presence of mandibular tori in the premolar regions has to be remembered. Illustrations in Sicher's "Oral Anatomy"[4] show landmarks (Figs. 40 & 41 and Figs. 265-271) and should be carefully studied. These ridges are of importance, not only because of the radiopacity they produce, but also because they may influence positioning of the film and angulation of the roentgen projection.

Involvement of a bifurcation located either on the vestibular or the oral surface of a tooth can be localized by this technique. In the roentgenograms shown in Figure 4, radiolucency can be seen at the bifurcation in both first and second molars. This roentgenogram was taken at a right angle (0°) projection. In the plus twenty-five degree projection, the radiolucency in the bifurcation of the second molar appears enlarged and that of the first molar, reduced. At a minus twenty-five degree angle, the second molar radiolucency appears smaller, but the first molar radiolucency appears enlarged. These illustrations of roentgenograms taken at various angles indicate that the involvement of the bifurcation of the first molar is on the oral side and that of the second molar is on the vestibular side. This can be explained and understood by a diagram (Fig. 5) which shows that if the lesion at the bifurcation is located on the vestibular side, it appears enlarged in a plus twenty-five degree angle projection and becomes smaller or disappears in a negative angle projection. The overlapping shadow of the oral enamel

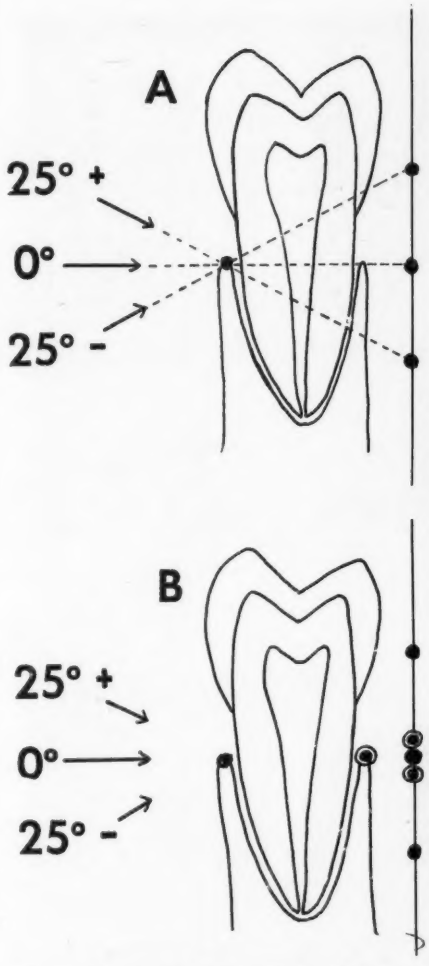


Fig. 3. Diagrammatic illustration of differences in extent of distortion created by various angles of projection, dependent upon the distance of the object from the film. A. Image of object on vestibular crest shifts for a great distance apically or coronally. B. Image of object on oral alveolar crest remains relatively stationary.

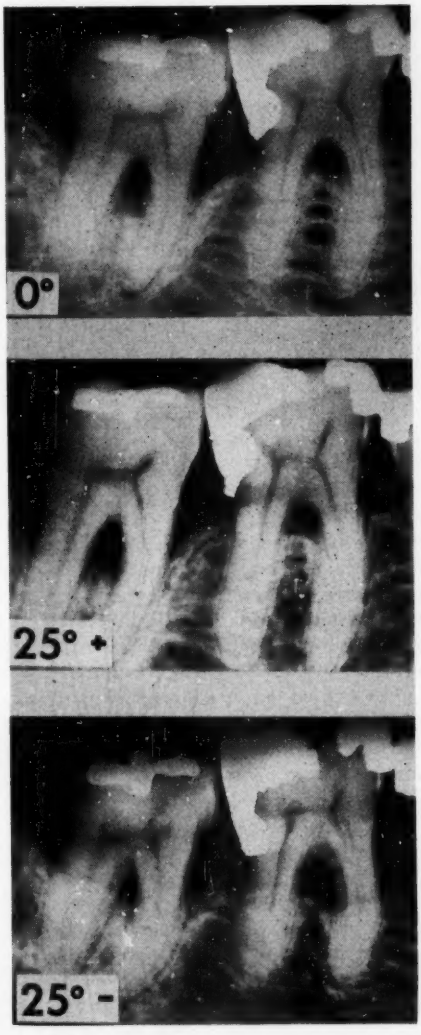


Fig. 4. Roentgenogram taken at a right angle (0°) projection reveals radiolucencies in the bifurcations of both first and second mandibular molars. In a positive twenty-five degree projection the radiolucency of the second molar increases; that of the first molar decreases in size. The reverse situation occurs with a minus twenty-five degree projection. The reason for the difference is that the radiolucency of the second molar is due to bone loss on the vestibular side, whereas the defect on the first molar is on the oral side.

margin in the negative angle projection might be an important factor in obliterating the radiolucency.

If the involvement of the bifurcation is on the oral side, it diminishes in size or disappears in a plus twenty-five degree angulation, largely due to overlapping shadow

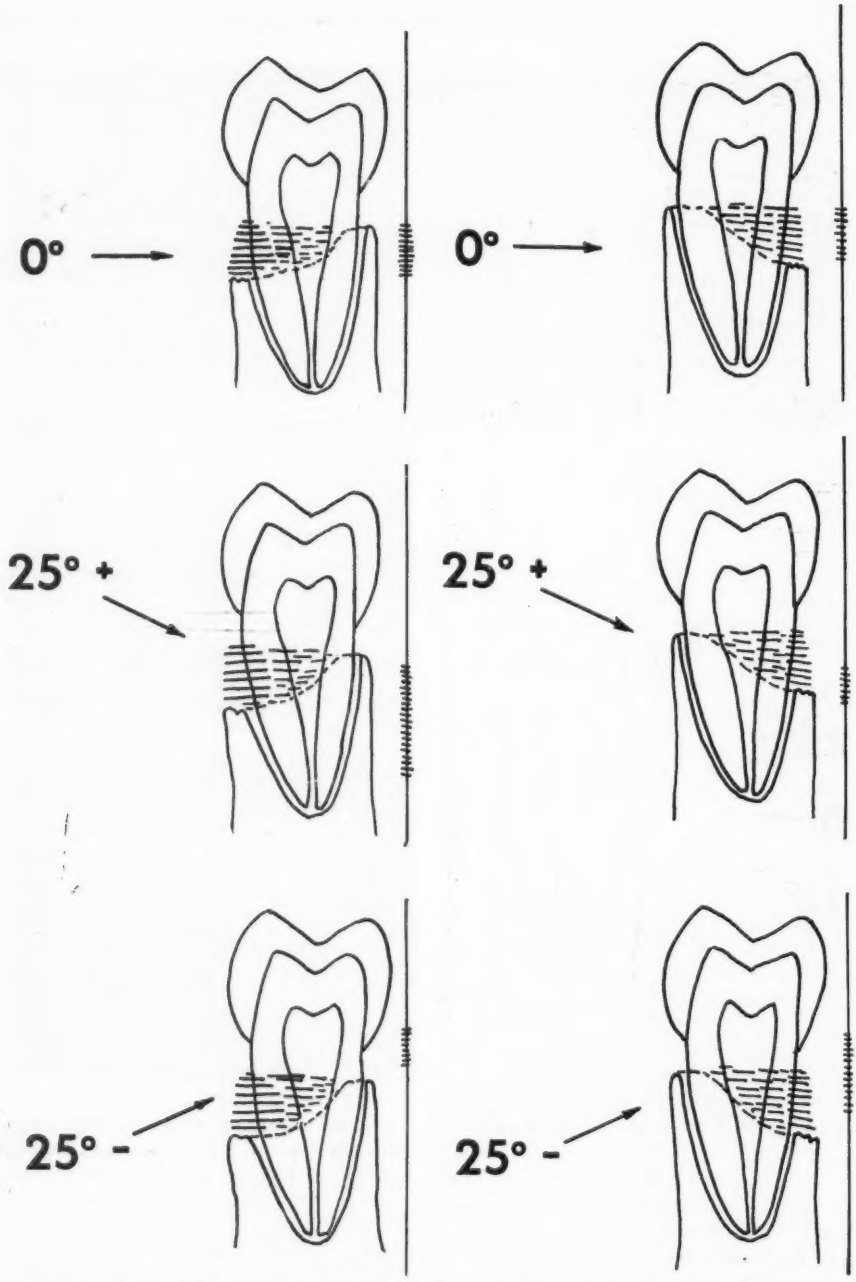


Fig. 5. Diagrammatic illustration of the effect of changed angulation of roentgen projection of bifurcation involvements. The vertical lines indicate the position of the film. The arrows indicate the general direction of roentgen rays. The horizontal lines in the sketch indicate the extent of bone loss and the horizontal lines on the film indicate the extent of the shadow of radiolucency caused by bone loss. Bone loss on the vestibular side is enlarged in a positive-angle projection and decreased in a negative-angle projection. Bone loss on the oral side is decreased by positive angulation and increased by negative projection.

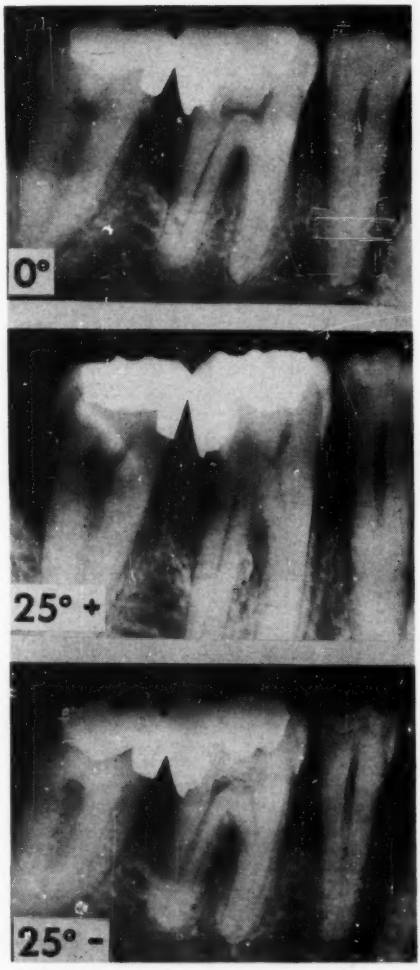


Fig. 6. The true outline of bony defects can be visualized by various projections. In a right angle (0°) projection, two bony outlines are recognized. From this projection alone, one cannot tell with certainty whether the vestibular or oral crest is decreased by resorption. A positive twenty-five degree angle projection decreased the difference between vestibular and oral bony margins; a negative increased the distance. From this shift of images, one can conclude that in this case the bone loss is on the oral alveolar crest.

of the vestibular margin of the enamel, but in a twenty-five degree negative angle, the radiolucency becomes more distinct and slightly enlarged.

In the diagram, no consideration is given to the divergence of the roentgen rays. They are more divergent if a short cone is used and more parallel if a small diaphragm and long cone are used. The arrows in the diagram merely indicate the direction of the main roentgen rays.

The true outline and shape of bone loss can better be visualized if projections are made at various angles. In the right angle (0°) projection, roentgenogram shown in Figure 6, bone loss is seen to be located in areas of the premolar and molar region. Two bony shadows are visible in this roentgenogram. One is lighter, the other heavier. This might indicate that the heavier shadow is that of the oral alveolar bone, but it also might be due to thickness of either the vestibular or oral plates. It certainly is due, in some degree, to the fact that in this area the vestibular and oral alveolar plates overlap and the shadow is that of both. A roentgenogram taken at a plus twenty-five degree angle, shows the two crests overlapping. In a negative angle projection, the two shadows again separate, even more than in the zero degree exposure. These roentgenograms clearly indicate that the bone loss in this area is disto-oral to the roots. The vestibular alveolar bone shifts apically in the positive angle and coronally in the negative angle projection, whereas the oral crest remains relatively stationary. Previous diagrams will help in understanding these roentgenograms.

If metal fillings are present in the crown of a tooth, especially in a vestibular or oral pit, their shift in projections at various angles might serve as useful reference points.

A good illustration of the value of taking roentgenograms at different angles and thus creating a three-dimensional image in one's mind, is shown in Figure 7. In the zero-degree angle projection, bone loss is evident

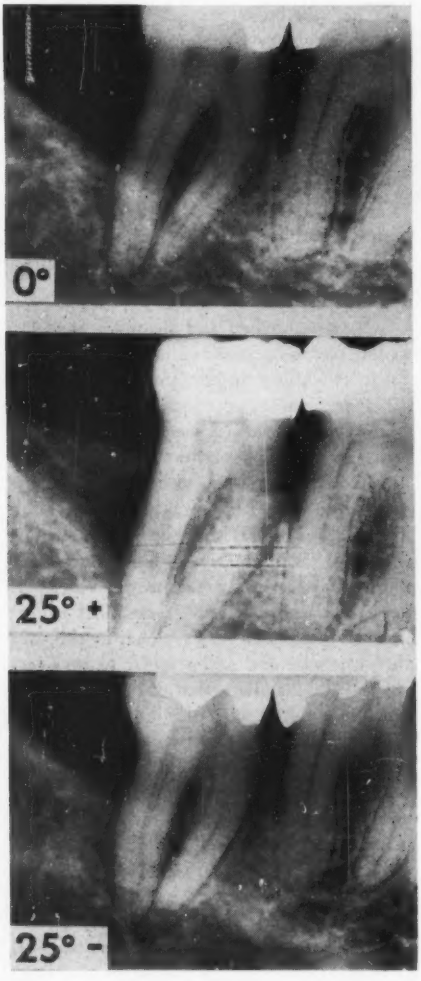


Fig. 7. A right angle (0°) projection of the roentgenogram shows bone loss on the distal surface of the second mandibular molar. The positive twenty-five degree angle projection reveals an intra-alveolar defect, extending toward the oral surface. The minus twenty-five degree angle projection almost completely obliterates the intra-alveolar crater because of the very heavy oblique line of the ramus of the mandible (compare with Fig. 1).

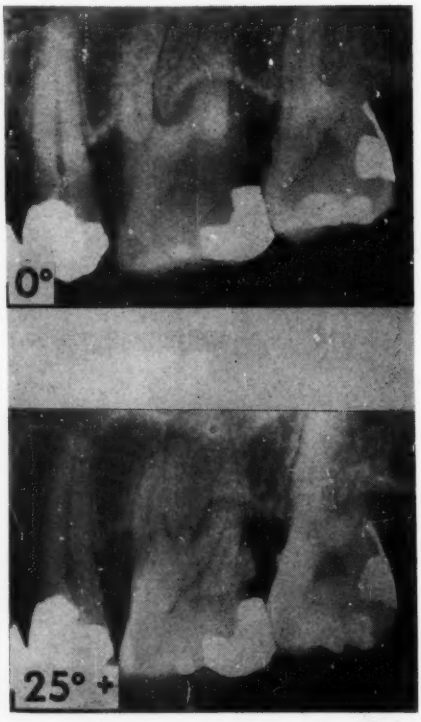


Fig. 8. Bony defect of alveolar crest in maxillary premolar and molar area, as seen in a right angle (0°) projection. At a plus twenty-five degree projection, the difference between the shadow of vestibular and oral alveolar plates increases. This fact indicates that the bony defect is on the palatine crest and extends from the oral side into the trifurcation area.

distal to the second molar. There is a heavy bone ledge extending distally from this tooth, which corresponds to the oblique line on the vestibular surface of the ramus of the mandible. The thinner oral bone is visible as a lighter shadow coronal to the heavy vestibular shadow. In a plus twenty-five degree angulation, the bone loss appears as a crater, distally and orally located. The minus twenty-five degree angulation almost completely obscures the bone loss because the heavy vestibular bony ridge overlaps the crater and the thinner oral bone.

If a three-dimensional picture is desirable in maxillary molar areas, a combination of

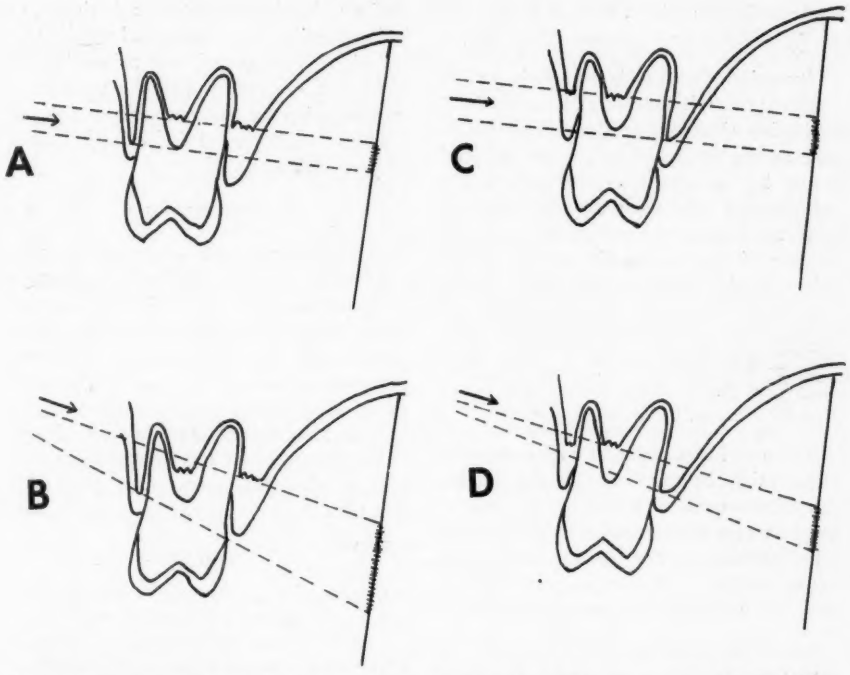


Fig. 9. Diagrammatic illustration of the localization of loss of bone at the alveolar crest in a maxillary area, as visualized by using right angle projection (long cone technique) and a positive twenty-five degree angle projection (short cone technique). If bone loss is on the oral side (A), the width of the radiolucent area increases with a positive twenty-five degree angle projection (B). Of bone loss is on the vestibular side (C), the width of radiolucency does not increase by the use of a twenty-five degree positive angle projection. Bone loss of the vestibular alveolar crest is often obscured by the heavy palatine bony plate.

long cone and short cone techniques can be utilized. For the zero-degree angulation, the long cone technique is used (Fig. 8). For the twenty-five degree positive angulation, the short cone technique can be used. Negative angle projections are very difficult to take in the maxillary area, but a zero-degree angulation and a positive angle projection can give satisfactory results.

In Figure 8 (0° angulation), a bony defect can be observed extending distally from the distal surface of the second premolar, involving the first molar, and to a lesser degree, the second molar. The most extensive involvement is at the mesio-vestibular root of the first molar. Two bony crests are observed. In the twenty-five degree positive projection, the difference between the two bony shadows has increased. In a diagrammatic illustration (Fig. 9), the location of the bone loss is explained as observed in these two roentgenograms taken at different angles. Figure 9A shows a right angle (0°) projection with the long cone technique. The film is placed away from the tooth, held in place by a hemostat and metal plate. The roentgen rays are parallel and at a right angle to the film. Assuming that the bone loss is on the oral side of the tooth and on the oral side of the mesiovestibular root, extending toward the trifurcation, the difference in the height of the vestibular and oral alveolar plates will produce a radiolucency on the film. With the same location of the film, but using a plus twenty-five degree

angle projection with a short cone, the size of the radiolucency increases (Fig. 9B).

Assuming that the bone loss is on the vestibular alveolar bone, a right angle (0°) projection (Fig. 9C) will show the difference in the height of vestibular and oral crests, by an area of radiolucency. The radiolucency might not be as pronounced as if the bone loss were on the oral side because of the heavier bony plate of the palate. With a positive twenty-five degree projection (Fig. 9D), the extent of the radiolucency increases only little and as in the previous roentgenogram (Fig. 9C), might be partly obscured by the heavy alveolar crest on the palatine side.

The use of short cone or long cone techniques might be questioned for this process. The short cone is preferable because it increases distortion which, in this instance, is of advantage. For routine roentgenograms used as an aid in periodontal diagnosis, the long cone technique is preferred.

In a recent article, Patur[5] discusses the merits of the long cone versus the short cone techniques in roentgenographic interpretation of alveolar bone changes but does not recommend variation of angulation for diagnostic purposes.

The technique of taking roentgenograms at various angles is not a new procedure. This technique is used in locating foreign bodies embedded in bone or soft tissues, or in localization of an embedded tooth. This technique is suggested here primarily as a method of studying and teaching the exact interpretation of roentgenograms, but it can give very useful information under certain conditions.

CONCLUSIONS

Proper interpretation of roentgenograms requires good roentgenographic techniques and knowledge of anatomic features and their roentgenographic appearance. One can improve the understanding of roentgenographic images by studying pictures taken of the same area at various angles. It is thus possible to create a three-dimensional picture of an area involved and thus have a clearer concept of a pathologic situation.

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Histogenesis of Repair after Mucogingival Surgery

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IN recent years, a variety of surgical techniques have been introduced to cope with periodontal problems involving the gingiva and the contiguous alveolar mucosa. These techniques are designed to retain or to create a functionally adequate zone of gingiva where it is absent or where gingivectomy would sacrifice most or all of the attached gingiva. Many of these techniques involve baring a variable portion of the alveolar crest to permit the regeneration of new gingival tissue. As the clinicians' perspective increased, variations of techniques were introduced to meet specific problems. With a variety of techniques available, it became important to know the origin of the granulation tissue that forms the new gingiva. The clinician needs a clear understanding of the mechanism of healing of the wound surface to be able to use predictable procedures.

Since these procedures are relatively new, definitive histologic evidence on the origin of the granulation tissue following the baring of the alveolar crest is not available. The subject has become a matter of considerable interest and debate. In many ways, the discussion on the mechanism of wound healing following mucogingival surgery resembles the endless argumentation that the subject of reattachment has provoked. Just as in reattachment, the strongest substantiating data on healing following mucogingival surgery is histologic evidence. The weakest evidence submitted is the highly subjective clinical observation and the sometimes non-sequitur reasoning made on the basis of such observations.

To clarify the mechanism of wound healing following the baring of the alveolar crest and vestibular bone, a histologic investigation using experimental animals was initiated. It was proposed to create a surgical wound simulating that produced by specific types of mucogingival surgery. The experimental procedures exposed the dentogingival junction and vestibular bone by excising the gingiva and periosteum over this area. The healing was observed microscopically by sacrificing the animals at specific post-surgical periods.

An appreciation of the problem at hand must be based on an understanding of the form and function of the tissues involved. This will give a ready reference point from which to compare the new tissue that will replace the previously lost or excised gingiva. The relation of form to function is obvious. Gingiva is a tissue well adapted to withstand the forces of friction and pressure of mastication and oral physiotherapy. It is an immovable tissue interposed between the movable tissues of the free gingiva and the alveolar mucosa.

Gingiva is characterized by a thick, keratinized epithelium that covers the underlying dense, firm collogenous fiber bundles of the lamina propria; these are immovably attached to the teeth and alveolar bone. The gingiva joins the alveolar mucosa along a scalloped line, the mucogingival junction. In contrast to gingiva, the alveolar mucosa has a relatively thin non-keratinized epithelium. The lamina propria and submucosa is loosely attached to the deep structures to permit movement of the lips, cheek and tongue.

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Gingiva is well adapted to withstand the functional stresses of pressure and friction to which it is normally exposed. The alveolar mucosa, because of its structure, is poorly adapted to such function. The recognition of the structural differences between the gingiva and the alveolar mucosa and the adaptation of this differing structure to function is the key to the understanding of the possible adverse effects that might result if gingiva is lost due to disease or surgical procedures. If the gingiva is lost or inadequate in extent, the remaining alveolar mucosa is poorly adapted to resist normal functional stresses of mastication and physiotherapy. Successful elimination of inflammation and pockets would not correct the inadequate situation that would result because of an inadequate zone of gingiva or a soft tissue margin of alveolar mucosa. The various techniques that comprise mucogingival surgery were developed in answer to the obvious need of creating and retaining a functionally adequate zone of gingiva.

CLINICAL STUDIES

Mucogingival problems have been classified by various authors. Orban[1] lists the clinical indications for mucogingival surgery and suggests the term gingival repositioning operation to indicate the procedure. Nabers,[2] first, and Ariaudo and Tyrell[3] later, described repositioning of the attached gingiva. Other synonymous terms suggested are gingival extension operation by Gottsegen;[4] pushback, pouch operation and local extension of vestibular trough by Goldman, Schluger and Fox.[5]

Friedman[6] in a clinical study observed the healing following mucogingival surgery involving the excision of the gingiva and baring the bone, and then concerning the origin of the gingiva in healing he states:

> It has been contended that the new gingiva is formed from granulation tissue which comes from bone, and that a functional adaptation may occur to produce gingiva. It is important to know the origin of the granulation tissue that produces the new gingiva. Since we are dealing here with attempts at extending and creating new attached gingiva where it did not exist, the surgery is done without prognostic conceptions unless we know if we will get new gingiva and how it is achieved. Therapeutically it becomes important to have this knowledge, and having it permits a wide range of surgical planning and a reasonable prediction of the results of the procedures.
>
> The granulation tissue has three probable sources in the wound area. It may come from the cut edge of the alveolar mucosa, the bone, or the cut edge of the gingiva. From clinical observations of operations such as the pushback, where large areas of bone were exposed, the author noted that the tissue granulated from the interproximal gingival papillae and circled the cervical areas of the teeth. In the early stages of healing, then, there would be a thin rim of granulation tissue (or newly formed gingiva) around the cervical area of the teeth, an island of exposed bone, and the cut edge of the alveolar mucosa. As the healing progressed, the narrow band of gingiva would granulate apically until gradually it covered the bone and joined with the slowly granulating edge of the alveolar mucosa. The rapidity with which the gingiva granulates, in contrast to the alveolar mucosa and bone, accounts for the new gingiva and the increased zone of attached gingiva noted.

HISTOLOGICAL STUDIES

Further studies at the histological level were attempted in order to answer the questions: (1) what is the nature of the "new" gingiva? (2) what is the origin of the gingiva? (3) what is the rate of healing? (4) what is the mechanism of healing of this new tissue?

Human histological studies have described the differentiation of replacement tissue Grant,[7] Ivancie.[8] After repositioning the gingiva apically, it was evident that alveolar mucosa with elastic fibers were replaced by collagenous connective tissue within eight months. Epithelial ridge formation, keratinization and orientation of mature collagen fiber bundles may be a result of functional adaptation. The new tissue is described as a less-differentiated and functional immature gingiva.

No clear cut studies relative to the origin, rate of healing and mechanism of healing of wounds after mucogingival surgery, have appeared in the literature. However, reference to previous studies of wound healing of mucous membranes, though less complex in nature, may shed some light on this problem.

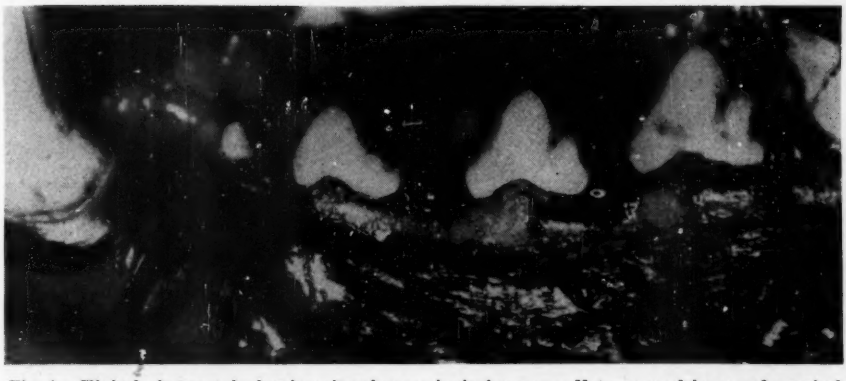

Fig. 1. Clinical photograph showing site of mucogingival surgery. Note exposed bone and surgical flap sutured to periosteum of alveolar mucosa.

Abrasion of the gingiva (Kollar, Wentz, Orban)[9] with aluminum oxide by an abrasive technique induced a low vascular response with minimal inflammatory cellular reactions. Healing began at twelve hours with epithelial cell migration from the borders of the wound. Within eighteen hours the epithelium completely covered the wound. Epithelial mitosis was evident at twenty four hours.

Mittelman[10] made a stab wound in the gingiva, one centimeter long and one and one-half millimeters deep, and within twenty four hours, the wound was covered by epithelium. Epithelial regeneration was complete at forty eight hours and was more rapid than connective tissue regeneration, since at seventy two hours the connective tissue still had not shown a complete repair.

When the gingiva above the bottom of the pocket was removed (Orban and Archer),[11] regeneration occurred by proliferation of granulation tissue from the excised lamina propria within four to nine days. At fourteen days the epithelium covered the wound.

A survey of the literature indicated the mechanism of healing, following complete excision of the gingiva in a circumscribed area, needs investigation. The questions of timing, where, how and how much repair of the tissue actually occurs should be answered. Another objective is to correlate these findings to the more careful clinical studies.

MATERIALS AND METHODS

This study is based on histological examination of the maxillary and mandibular premolars of ten young dogs following mucogingival surgery. The experimental surgical flap consisted of the buccal half of the gingival papilla, the vestibular, marginal and attached gingiva with the underlying periosteum. The base of the flap was located at a point beneath the mucogingival junction. Following the reflection of the flap, it was excised and the wound edge was sutured to the periosteum of the alveolar mucosa. The wound, after the flap excision, measured 5 x 32 mm. (Fig. 1). All remnants of tissue to the tooth and alveolar bone were removed by scraping and polishing tooth with a rubber wheel. A postoperative injection of 600,000 units of penicillin was administered intramuscularly to prevent infection. Sutures were removed after seven days. A soft diet of pulverized dog meal was fed throughout the experiment.

Animals were sacrificed at 0 hrs., and then at intervals of 2, 4, 6, 10, 14, 21, 28, 93, and 185 days. The premolars of the unoperated opposite left mandible and maxilla were also sectioned and served as

controls. The sections were stained with hematoxylin and eosin, and with Mallory stain.

MICROSCOPIC FINDINGS

Immediately after surgery, a clot formed at the wound edges: Denuded bone in the central area, however, was free of hemorrhage. Within two to four days, the soft tissue edges of the wound were reddened, rolled, elevated, and a hemorrhagic exudate appeared. At this time the bone had a gray appearance.

The postoperative period of the sixth to the tenth day was marked by the appearance of a bright red, granular new tissue growth which covered the entire wound surface. Finally, the velvet like tissue covered the entire defect from margin to margin. Only a few small islands of bone were visible.

Fourteen to twenty-one days after the surgery, the rolled elevated wound lips appeared to have extended further into the central area. A collar of tissue, elevated higher than the surrounding area, was apparent around each tooth. The entire wound appeared to be covered by a smooth, glistening epithelium and no longer appeared bright red, but had dark red coloration.

At twenty-eight days healing was complete. The surface was smooth; the rolled irregular wound edges had disappeared and only a fine line indicated the position of the previous cut edge. The color was rose pink. This light pink color, together with lack of pigmentation and stippling contrasted with the surrounding unoperated tissue.

At ninety-three days the tissue at the site of the surgical flap was not rolled but firm and appeared well attached to the teeth. This new tissue did not appear to be pigmented or stippled at this time.

One hundred and eighty-five days after surgery, a slight pigmentation of the new tissue was apparent bordering the teeth. Stippling was not observed. The new tissue could still be distinguished from adjacent tissue because of the contrast of color and surface texture.

Fig. 2. Photomicrograph of 2 day postoperative specimen—maxillary interdental area (X12). Compare with Fig. 16, Illustration B. H & E Stain. The interdental bony septum consists of an inner spongy bone and an outer buccal vestibular and lingual oral plate of compact bone. A blood clot is present at the wound edges; however, none is present in central area of exposed bone (a).

MICROSCOPIC FINDINGS

Histologic study between two days and one hundred eighty five days showed three phases in the healing process. These phases are:

I. Osteoclastic phase—(2 - 10 days)
II. Osteoblastic phase—(10 - 28 days)
III. Phase of functional repair of dento-periodontal unit and dento-gingival junction—(28 - 185 days)

Two areas will be described; the tissues of the interdental area between the teeth and the tissues of the radicular area covering the root.

I. Osteoclastic Phase (2 - 10 days)

Fig. 3. Photomicrograph of 2 day postoperative specimen—mandibular radicular area (X12). H & E Stain. The exposed compact vestibular plate of bone has few marrow spaces. A clot (a) is present at the severed dentogingival junction and at the excised wound edge (b). Inflammation is present beneath clot.

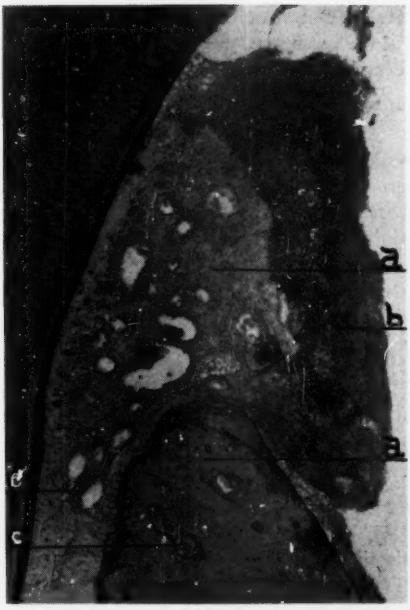

Fig. 4. Photomicrograph of 2 day postoperative specimen—mandibular radicular area. High power magnification of Figure 3 (X50). Compare with Fig. 16, Illust. C. H & E Stain. Proliferation of young connective tissue (a) is occurring beneath the clot (b) at cut periodontal ligament. Dilated blood vessels indicate presence of inflammation. A few osteoclasts are present in Haversian canals (c), alveolar crest (d), periodontal ligament (e).

Two days after surgery, a blood clot, with a superficial layer of degenerated cells, covered the wound edges. At the superior wound edge, in the area corresponding to the cut interdental papilla (Fig. 2) and in the severed dento-gingival junction (Fig. 3), the clot was well defined and in contact with the teeth above the exposed alveolar bone. At the lateral and inferior wound edges, the clot covered the space between the irregular edges of the wound and underlying bone. No clot was observed upon the exposed bone in the central wound area.

At four to six days, three layers in the clot would be distinguished; a superficial necrotic layer consisting of bacteria and cellular debris; a middle layer consisting of large number of polymorphonuclear leucocytes; a deep layer which was invaded by capillaries from below. Many fibroblasts with large nuclei could be distinguished.

The lamina propria beneath the clot at the interdental area, the incised periodontal tissue (Fig. 4) and the connective tissue at the base of the wound in the alveolar mucosa showed the presence of inflammatory cells. Inflammation was also evident in some of the Haversian canals of the compact vestibular plate (Fig. 4), and in the bone marrow spaces beneath the exposed bone (Fig. 5). By the fourth day, this inflammation had extended further into the deeper marrow spaces.

Two days after surgery empty lucunae were observed in the superficial layers of the exposed alveolar bone. The depth of the

acellular necrotic bone averaged .1 mm. In all the specimens, the remaining bone tissue beneath the necrotic layer appeared viable (Fig. 6).

An undermining pattern of resorption was observed as early as two days after surgery, while the greatest activity was apparent between four and six days. The activity diminished considerably between six and ten days, and little activity was observed at fourteen days. The osteoclasts differentiated in all areas of viable connective tissue close to exposed bone. Osteoclastic activity was observed in the connective tissue of the bone marrow beneath the non-vital bone (Fig. 5), the connective tissue of the periodontal ligament (Fig. 7), and in the connective tissue at the wound edges (Fig. 8 & 9).

The pattern of resorption varied with the detailed relation of anatomy of the part. Two zones, the areas of the interdental septa and the radicular areas over the roots, showed significant differences.

The interdental bony septum at the site of surgery consisted of an inner spongy bone and an outer buccal vestibular plate composed of compact bone. The oral plate of compact bone on the lingual was not included in the surgical procedure. The mesial and distal portion of the interdental septum was limited by the thinner alveolar bone of the teeth.

Osteoclasts appeared at two and four days, postoperatively, in the marrow spaces of the interdental areas beneath the vestibular plate and in the Haversian canals of the vestibular plate. Osteoclastic activity also was evident in the bone covered by connective tissue forming the periosteum at the inferior wound edge in the alveolar mucosa. In a similar manner, osteoclastic activity occurred at the wound edge of the septal crest.

The greatest osteoclastic activity occurred between four and six days. This osteoclastic action resulted in an enlargement of the marrow spaces and Haversian canals.

Fig. 5. Photomicrograph of 2 day postoperative specimen—maxillary interdental area. High magnification of Figure 2 (X50). H & E Stain. Fibrous type of marrow (young connective tissue) with osteoclasts is present in marrow spaces (a). A clot extends over exposed vestibular bone at the wound edge (b) and from an opened marrow space (c).

Finally, the result of this resorption, as it occurred from the marrow spaces below and at the periosteal wound edges above, was the complete disappearance of the vestibular plate and crestal bone. Now the configuration of the interdental area was that of a flat slope from crest to wound base in the alveolar mucosa. With this loss of the vestibular and crestal compact layer of bone, the deeper spongy bone and marrow was exposed. Here a granulation tissue (Fig. 10) consisting of many capillaries, young fibroblasts and polymorphonuclear leucocytes, had replaced the characteristic fat cells of normal marrow.

Through the six to ten day period, osteoclastic activity declined, osteoblastic activity increased. The rebuilding of bone tissue occurred first in the deeper bone marrow spaces.

Fig. 6. Photomicrograph of 2 day interdental postoperative specimen (X350). H & E Stain. Bone necrosis, on the external surface of operative site, is evident by the empty lucunae (a). Vital bone (b) is present below this necrotic layer. Covering the necrotic plate is a remnant of periosteum (c) which was not removed.

In the operated radicular area, the labial alveolar bone proper is fused with the vestibular plate without the supporting spongy bone, as found in the interdental septum. Therefore, in contrast to the interdental septum, the fused bony plates of compact bone contained only Haversian canals and a few marrow spaces. Near the fundus of the tooth, spongy bone intervened as the diverging vestibular plate separated from the alveolar bone proper.

In the early experimental periods of two and four days osteoclasts, frequently, differentiated in the severed periodontal tissues. This area, pre-operatively, was the site of the dento-gingival junction. Within six days, in the periodontal ligament, undermining osteoclastic resorption occurred on the periodontal side of the exposed vestibular plate of bone. This resulted, first, in a widening of the periodontal space and, finally, in a progressive loss of the alveolar crest until the entire exposed bone was lost. This process occurred within a ten day period (Fig. 8 & 9). At fourteen days the resorption process in all areas had ended.

While the removal of the necrotic bone starts by undermining resorption, in the interdental and radicular areas, the bone in the area at the immediate wound edge showed frontal resorption despite the absence of bone necrosis. Osteoclasts were present in the connective tissue overlying this viable bone.

At two and four days after injury, a proliferation of young connective tissue was observed beneath the clot at the wound edges and cut periodontal tissue. As undermining resorption progressed and the vestibular plate of bone disappeared, the underlying bone marrow was exposed. Young connective tissue proliferated from the exposed bone marrow, replacing the resorbed bone. This young connective tissue extended from wound edge to wound edge in both the radicular area and the interdental area (Fig. 9 & 10). At the fourteen day period the young connective tissue exhibited a definite collagen fiber formation.

II. Osteoblastic Phase (10 - 28 days) Osteoblastic activity began while osteoclastic resorption was still a prominent feature. At ten days, rebuilding of new bone was observed in the deeper bone marrow (Fig. 10). The new bone was identified as osteoid tissue outlining the trabeculae. In the same period, peripheral to the active frontal resorption site of the wound edge, osteophytes began to form. At times, osteophytic bone formation extended into areas of resorption. The osteophytes exhibited a pattern of trabeculae formation that was just perpendicular to the original bone surface and later fused at external ends. The osteophytic trabeculae were coarse fibillar bone covered by osteoid tissue and osteoblasts.

The 21 - 28 day period marked the time of the greatest bone formation. This occurred at the site of resorbed bone in the connective tissue covering the wound, both in the interdental (Fig. 11) and radicular areas (Fig. 12). Both the interdental

Fig. 7. Photomicrograph of 6 day postoperative specimen—maxillary radicular area (X50). H & E Stain. Osteoclastic activity (a) is occurring all along the periodontal surface of the alveolar bone. Inflammation is evident in the periodontal ligament. A bacterial plaque is present on the exposed bone surface (b).

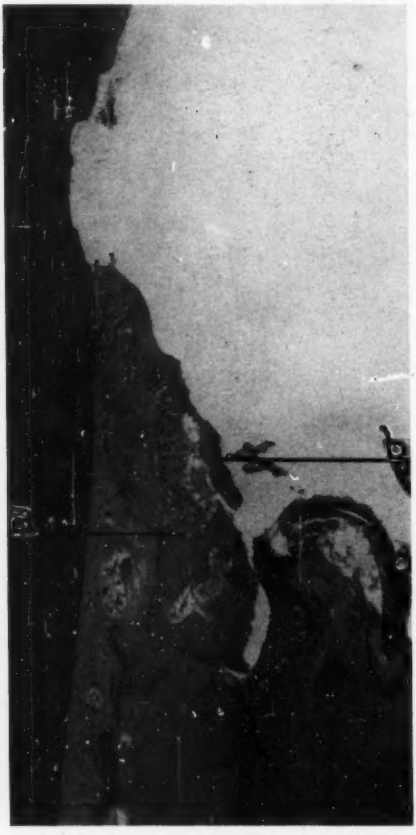

Fig. 8. Photomicrograph of 10 day postoperative specimen—mandibular radicular area (X50). Compare with Fig. 17, Illust. B. H & E Stain. The tip of the alveolar crest has been resorbed (a). Below this, the periodontal space is wider. Notch in tooth is an artifact. Small sequestrum is seen (b) and the suture (c) used in the experiment.

(Fig. 11) and the radicular areas (Fig. 12) showed trabecular formation of coarse fibillar bone outlined with osteoid tissue and osteoblasts. Simultaneously, with the bone formation in the radicular area, there was periodontal apposition of alveolar bone proper (Fig. 12).

The epithelial cells at the wound edge of the interdental papilla and sutured base, two days after surgery, migrated a short distance over the incised connective tissue and stopped at the clot.

The interdental specimens, at six to ten days, exhibited a continued proliferation of epithelium from the cut papilla and cut sutured edge over the young connective tissue of the wound. Some areas were covered with epithelium but in general, the proliferating epithelium from the papilla had not contacted that from the base. The basal cell layer was well differentiated, and a disorganized, less differentiated prickle cell layer was evident with large desquamated epithelial cells on the surface. The presence of polymorphonuclear leucocytes between the epithelial cells indicated their

Fig. 9. Photomicrograph of 10 day postoperative specimen. Higher magnification of Figure 6 (X50). Compare with Fig. 17, Illust. B. H & E Stain. Undermining resorption occurs in the periodontal space (a) and marrow spaces (b), while frontal resorption is evident on surface of the vestibular bony plate below wound edge (c). The crest has been resorbed. Inflammatory reaction occurring in the proliferating young connective tissue of the former periodontal space (f), bone marrow, and at the sutured wound edge. A sequestrum (d) is almost exfoliated and covered on the surface by bacteria. Apposition of bone is evident below exposed area in the periodontal space (e).

migration through the epithelium to the surface.

In the interdental area, fourteen to twenty-one days after surgery, the epithelium had covered the entire surface area as a narrow sheet of cells with definite, though irregular, ridges. The epithelial layer was thickened near the cut papillae, while near the cut suture area, the epithelium was narrow and lacked ridges. Similarly, the radicular area displayed a new marginal epithelium that was thickened and exhibited irregular ridge formation. The remaining new epithelium of the radicular area adjacent to the cut suture base was narrow

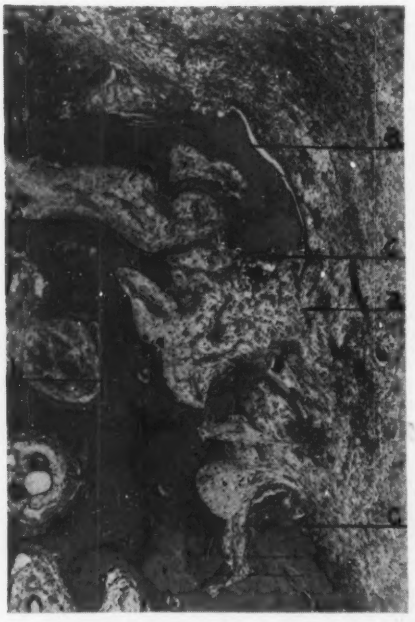

Fig. 10. Photomicrograph in the vestibular area at 10th postoperative day—mandibular interdental area (X50). Compare with Fig. 16, Illust. C. H & E Stain. Young connective tissue is present in the marrow spaces, extending to completely cover the operatively exposed bone (a). Increased osteoblastic activity is exhibited by osteod tissue seam covering the trabeculae of bone (b). Some osteoclastic activity is still observed on the external surface of the bone (c).

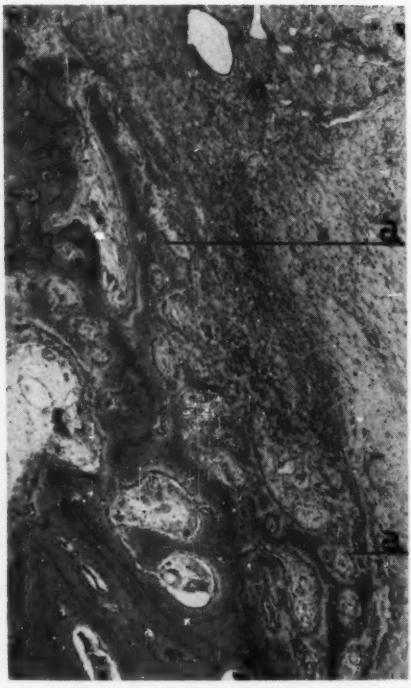

Fig. 11. Photomicrograph of 28 day postoperative specimen—mandibular interdental area (X50). Compare with Fig. 16, Illust. D. H & E Stain. Coarse, immature, trabeculae outlined with osteod tissue and osteoblasts indicates this period of greatest bone formation (a). This occurs at the site of resorbed bone in the collagenous connective tissue now covering the wound.

and lacked ridges. A new epithelial attachment could be observed on the root of the tooth. This was the first indication of the formation of a new dento-gingival junction.

III. Phase of functional repair of dento-peridontal unit and dento-gingival junction (28 - 185 days). The vestibular bone, at twenty-eight days, displayed immature, coarse, fibrillar trabeculæ at the sight of previous resorption (Figs. 11 & 12). Within ninety-three days, the immature trabeculae of osteophytic bone was replaced largely by intermediate type of bone forming a compact bony plate. This intermediate type of bone described by Weinmann and Sicher,[12] consisting of irregular arranged fibrils, lacking lamellation, as compared to the adjacent mature bone that exhibits an alternation of fiber direction and displays lamellation. Slight periosteal apposition occurred on the new vestibular plate. Apical to the apposition, the periosteal bone surface presented Howship's lucanae indicating active resorption. At one hundred and eighty-five days after surgery, apposition and resorption were evident to a slight degree.

The complete regeneration of the interdental alveolar septa was significant (Fig. 13). The examination of the radicular area showed an entirely different picture. The vestibular alveolar bone crest at this site was at a lower level than the original alveolar bone crest (Fig. 14). As was stated in material and methods, all animals had an equal vertical strip of bone exposed that averaged four to five millimeters. All ex-

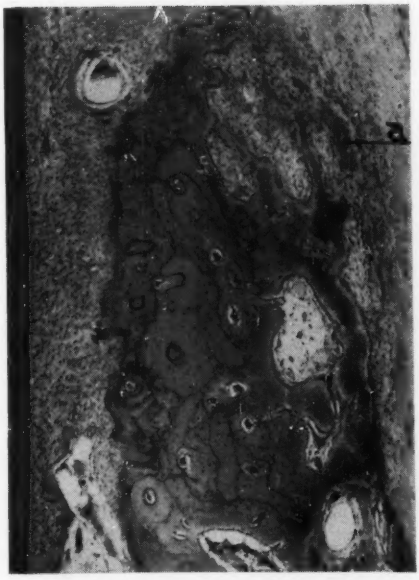

Fig. 12. Photomicrograph of 28 day postoperative specimen—mandibular radicular area (X50). Compare with Fig. 17. Illust. C. H & E Stain. Osteophytic bone trabeculae (a) formation at the lowered labial alveolar crest in the radicular area.

Fig. 13. Photomicrograph of ninety-three day postoperative specimen—mandibular interdental area (X12). Compare with Fig. 16. Illust. E. H & E Stain. Complete regeneration of the interdental septum of bone has occurred (a). The marrow tissue is of a normal fatty type. Some subepithelial inflammation is present in the collagenous connective tissue. The epithelium is thick and contains only a few ridges.

posed bone in the radicular area was completely resorbed within six to ten days. Measurements revealed that only 2.5 millimeters of bone had regenerated.

When stained by Mallory's method, Sharpey's fibers in the bone and a definitive intermediate plexus were evident in the periodontal space by the twenty-first day. At twenty-eight days, more Sharpey's fibers were evident.

It was apparent that within the ninety-three day postoperative period, apposition of the alveolar bone proper had now completely restored the width of the periodontal space (Fig. 14). In the area subjacent to the regenerated bone, the periodontal ligament appeared normal with an arrangement of cells and fibers perpendicular to the tooth root surface and new bone. A layer of cementoid was present on the surface of the cementum at the wound site at ninety-three days.

In the period of functional adaptation, residual chronic inflammation in the papillary layer of connective tissue diminished considerably from ninety-three to one hundred eighty-five days after surgery, however, continued to be present. The collagenous fiber bundles of the connective tissue, in the wound area, at one hundred eighty-five days, displayed a distinct orientation running between the epithelial ridges and at right angles to the surface mucosa.

Previously, the epithelium exhibited only a well differentiated basal cell layer, but by the twenty-first and the twenty-eighth day there was, in addition to the basal cell layer, evidence of distinct prickle cell layer with desquamated cells on the surface. Acanthosis of marginal and interdental papillary epithelium was evident with some ridge formation. However, the epithelium that proliferated from the base was fourteen cells thick and appeared as a thick even band. An increased ridge formation

was present in both the ninety-three and one hundred and eighty-five day specimens. The ridges were comparable to those found in the gingiva of normal specimens. Pigment in the new epithelium and underlying connective tissue was evident in the one hundred and eighty-five day specimen.

A granular layer of cells was never distinguishable in the dogs; however, a dense superficial prickle cell layer was present with elongated cells whose long axis was parallel to the epithelial surface. Keratin was never observed in the marginal and attached gingiva. Parakeratosis did occur in the normal specimen, and was evident in the operated areas by the ninety-third day.

The functional repair of the dentogingival junction was evident with the attachment of the connective tissue and epithelium to the roots in the radicular areas. By the twenty-first day, the connective tissue of the new connective tissue junction, coronal to the repaired crest had formed the fibrous attachment to the root of the tooth, measuring 1.98 mm., double the .98 mm. measurement of the control. This increased fibrous attachment remained throughout the experiment (Figs. 14 & 15). In contrast, the quantity of interdental connective tissue completely regenerated and replaced the tissue which was lost by mucogingival resection.

The epithelial attachment, in the control experiments, was on the enamel and ended at the cemento-enamel junction. However, the new attachment of the operated specimens exhibited a different position of attachment. Occasionally, the epithelial attachment had proliferated along the root of the tooth (Fig. 14). The epithelium attached to the dentin (Fig. 14), cementum (Fig. 14), and enamel (Fig. 15), but never on cementoid. The attachment was observed above, as well as below, and often in the notches on the tooth that were made by scraping the tooth to remove all tissue remnants (Figs. 14 & 15).

The new epithelium, that surrounded the tooth, migrated from the epithelium

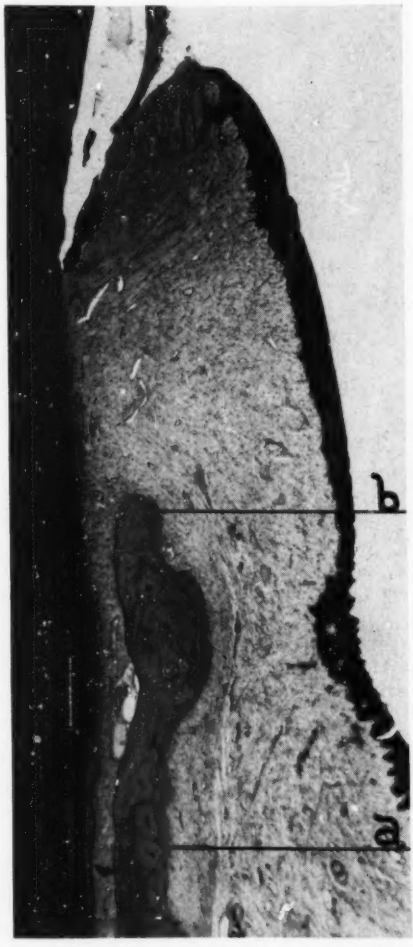

Fig. 14. Photomicrograph of ninety-three day postoperative specimen—mandibular radicular area (X12). Compare with Fig. 17, Illust. C. H & E Stain. The amount of regeneration of the alveolar bone is evident between (a) and (b). (a) indicates the alveolar crest after postoperative bone loss. (b) is the highest level of the alveolar crest regeneration at ninety-three days postoperatively. The connective tissue between the end of the epithelial attachment and alveolar bone is doubled. The epithelial attachment is attached to the cementum. The periodontal space has returned to a normal width.

at the wound edges and, fourteen days after surgery, attached to the tooth. Twenty-one days postoperatively, the epithelium, facing the tooth, exhibited a definite basal cell layer. A normal elongated prickle cell layer was exhibited at one hundred eighty-

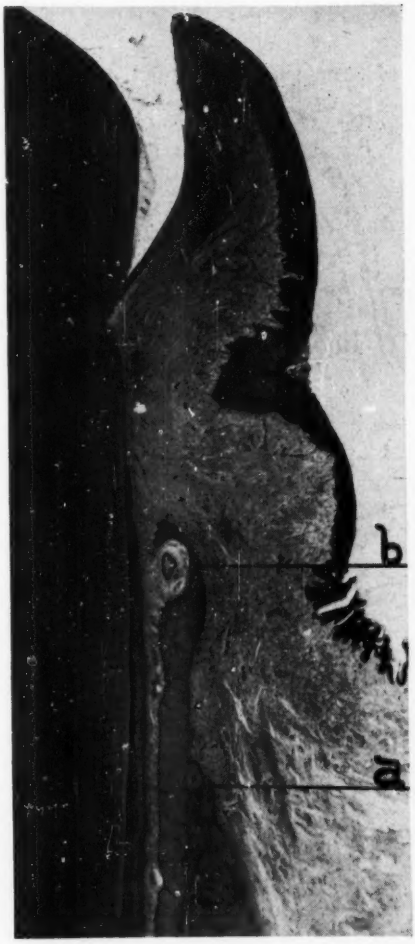

Fig. 15. Photomicrograph of one hundred eighty-five day postoperative specimen—mandibular radicular area (X12). Compare with Fig. 17, Illust. C. H & E Stain.

five days, in the absence of dental deposits. Where deposits were present, the superficial surface of the prickle cell layer showed enlarged degenerated cells. Epithelial strands proliferated into the underlying connective tissue in the ninety-three (Fig. 14) and one hundred and eighty-five day animals. In the last stage, the crevicular epithelium was a narrow eight to ten cell layer and contained a one or two cuboidal cell layer. The remaining cells were elongated and parallel to the tooth surface. The new epithelium facing the tooth resembled the crevicular epithelium of the normal specimens. The difference was that the normal specimen showed no long proliferating ridges. Dental deposits on the teeth may be an objectionable variable.

Finally, the new epithelium that covered the radicular areas, other than the crevicular epithelium, exhibited the same characteristics as the new epithelium that covered the interdental areas and resembled the epithelium of the controls.

DISCUSSION

The entire reaction following mucogingival surgery was a connective tissue response. Immediately after resection of the mucogingival flap with its periosteum, a superficial layer of exposed bone became necrotic. Early resorption of the necrotic bone could be achieved only by undermining osteoclastic activity. Osteoclasis began within two days and became most active between fifth and tenth day. Osteoclasts originated mainly from bone marrow spaces and small Haversian canals in the interdental area (Fig. 5), while in the radicular area, the principal source of resorption was from the periodontal surface (Fig. 7), and to a lesser degree from the small Haversian canals and few bone marrow spaces that existed in this area (Fig. 4). By the sixth day some frontal resorption occurred on the vestibular plate peripheral to the wound edges. Osteoclasts differentiated in all viable connective tissue close to bone.

The result was a removal of the exposed necrotic bone, and the viable vestibular plate beneath. Within six days, in the interdental area, the loss of the vestibular plate exposed the underlying spongy bone, and the remaining alveolar bone exhibited a ramping configuration from the lingual crest to the excised wound edge (Fig. 16 C). Simultaneously, in the radicular area, periodontal resorption caused, first, a widening of the periodontal space, and then a total loss of the exposed vestibular

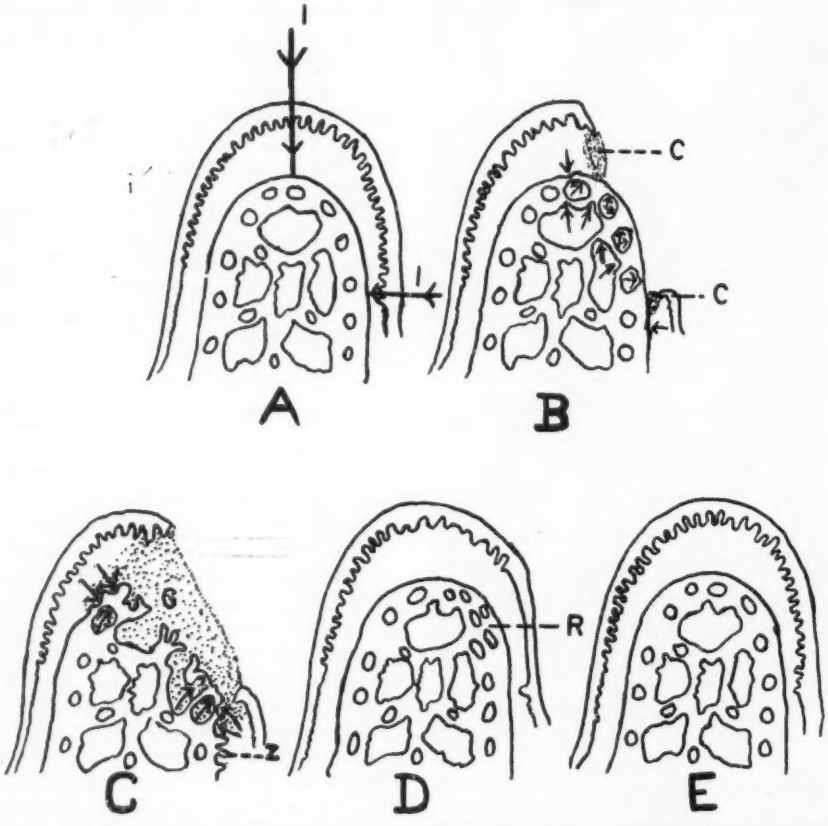

Fig. 16. Diagramatic illustration of the operative site at interdental area. (A) Normal. 1—direction of incisions. (B) 2 - 4 days—direction of resorption. C—blood clot and exposed bone between blood clots. (C) 6 - 10 days—direction of resorption. G—young connective tissue. Z—trabeculae formation —coarse, fibrillar bone. (D) 28 days. R—trabeculae bone formation at wound. (E) 95 - 185 days—return to normal.

bone (Fig. 17 B). As a result, the alveolar crest was considerably lowered, exposing the underlying periodontal tissue.

The difference in the anatomy of interdental and radicular areas was apparently responsible for the varied degree of the osteoclastic resorption. The repair of the alveolar bone also varied in degree in the two areas. It was of great interest that after resorption, where a broad scaffolding remained (the interdental area), the formation of new bone, within twenty-one to twenty-eight days, leads to a fairly complete restoration of the resorbed bone that was anatomically acceptable. In contrast, in the radicular area where the scaffolding was restricted to a narrow area or stopped on a compact plate, bone apposition never completely reconstructed the resorbed bone. Here only one-half of the bone was rebuilt, therefore, this wall of the socket remained low.

While regeneration of all tissue, including bone, occurred in the interdental areas, the radicular area, in contrast, exhibited only a functional repair of the dento-periodontal unit to the dento-gingival junction. To compensate for this lowered alveolar

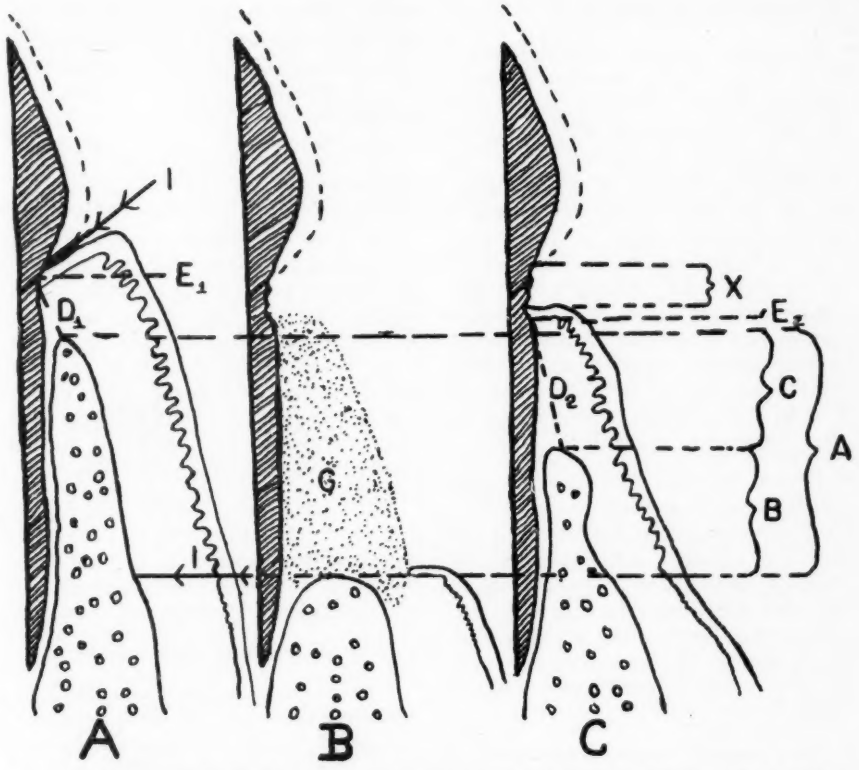

Fig. 17. Diagramatic illustration of the operative site at radicular area. (A) Normal. (B) 6 - 10 days. (C) 95 - 185 days. I—incisions—epithelium and connective tissue removed, baring the bone. A—5 mm. bone exposure and resorption. B—2.5 mm. new bone formation. C—2.5 mm. loss of bone. D_1—original connective tissue attachment. D_2—new connective tissue attachment. E_1—original epithelial attachment on cemento-enamel junction. E_2—epithelial attachment apical to cemento-enamel junction. X—epithelium at lower level. G—young connective tissue.

bone crest, the fibrous attachment of the new gingiva was double (1.98 mm.) the original (.98 mm.) gingiva. New attachment of the epithelium on the tooth was also not uniform. In the controls, the epithelial attachment was on the enamel; however, in operated specimens it was observed on the enamel, at the cemento-enamel junction, or in the majority of cases, on the root of the tooth.

The significance of these findings would seem to indicate that mucogingival surgery with removal of the periosteal tissues will lead to loss of alveolar bone and a final lower position of the dento-gingival junction on the tooth. One could speculate that less traumatic surgery, without removal of the periosteal tissues, might lead to less bone resorption and perhaps a higher position of the dento-gingival junction.

The most significant microscopic finding is the rapid formation of young connective tissue (granulation tissue) from the cut periodontal ligament and dento-gingival junction. This tissue appeared, within two to four days, as a collar surrounding the teeth. This was the tissue Friedman[6] clinically described as a rim of tissue (granulation tissue) around the cervical areas of the teeth and which, simultaneously, he described a "granulating apically" to join with the more slowly granulating wound

edge of the alveolar mucosa.

It can be concluded that this narrow band of "granulation tissue" at the cervical area did not proliferate apically until it gradually covered the bone and joined with the slowly granulating edge of the alveolar mucosa as stated by Friedman.[6] Instead, our experimental findings indicate that proliferating young connective tissue which differentiates into gingiva originated mainly from fixed connective tissue sites, namely, the exposed bone marrow spaces and exposed periodontal ligament tissue. A lesser amount occurred at the mobile sutured alveolar mucosa. The immovable fixation of proliferating young connective tissue seems to be essential.

It was stated[6] "the rapidity with which the gingiva granulates, in contrast to the alveolar mucosa and bone, accounts for the new gingiva and increased zone of attached gingiva notes". One cannot justify that this tissue differentiates to gingiva. In this investigation, a large portion of this proliferating connective tissue arose from the bone marrow and periodontal tissue.

There was no resorption of cementum in the wound area. During regeneration of this wound area, cementoblasts lined the cementum at twenty-one to twenty-eight days and a layer of cementoid was formed on the root of the tooth within ninety-three days.

Between ten and twenty-eight days, there was an increase in collagenous fibers in the wound area. In all the described areas, with collagen bundle formation, the connective tissue developed into a thick and uniform layer that shows the characteristics of gingiva. It was interesting to note the newly formed connective tissue (attached gingiva) was first attached to the bone and later gained attachment, above the alveolar crest, to the newly formed cementum. From this a new fibrous component of the dento-gingival junction was established. Significantly, the length of the regenerated fibrous attachment, the gingiva, above the alveolar crest, was double the original gingiva in the radicular area. This increase in gingiva compensated for the failure of complete regeneration of bone.

The apposition of bone restored the normal width of the periodontal space by the ninety-third day. Since the alveolar crest never completely regenerated, there was a loss in length of the periodontal ligament, an important supporting structure of the tooth. Thus, in the radicular area, the dento-gingival junction exhibited a soft tissue functional repair, with an anatomic bony deformity, and loss in extent of the periodontal ligament. Seemingly, the new attached gingiva will resist the stresses induced by food during mastication.

Little bone apposition occurred in the late phases (93 - 185 days) of the experiment and one can predict that the bone deformity and periodontal ligament impairment will always be present.

SUMMARY AND CONCLUSIONS

This investigation represents a histologic examination of repair of the oral mucosa and the dento-gingival junction on ten young dogs. A mucogingival flap was reflected in these animals, a measured strip of the mobilized flap excised, and a predetermined area of alveolar bone was left exposed.

1. The repair of the wound was complicated by a necrosis of the superficial layer of exposed bone. This was followed by an undermining resorption and, finally, at the two to fourteen day postoperative period by the complete loss of the exposed vestibular bone.

2. The most significant finding was the source and rate of the proliferating young connective tissue. Two days postoperative, the fixed connective tissue of the cut dento-gingival junction and the periodontal ligament, the incised gingival papillae and the lateral wound edges were the sources of the initial granulation tissue. At six days, after the resorption of the vestibular plate,

the granulation tissue from the marrow spaces and periodontal ligament fused with the initial granulations from the fixed wound edges to cover the defect. Finally, there was a junction of these rapidly growing tissues with the alveolar mucosa.

3. New bone formation was greatest between the twenty-first and twenty-eighth day period.

4. Microscopic findings indicated that a complete regeneration of the oral mucosa occurred in the interdental area. In the radicular area of the wound, the dentogingival junction exhibited a functional repair with an anatomical deformity. Only one-half of the bone was rebuilt at this site.

5. The epithelial attachment occupied a more apical portion, post-surgically, than the control.

6. The wound was covered by a new connective tissue within fourteen days and by epithelium in twenty-one days.

7. Complete maturation and functional orientation of the involved tissues extended over a six month period.

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Drs. Henry M. Goldman and D. Walter Cohen will present a one day course on the Use of Ultrasonics in Periodontia, Saturday, 17th December 1960. The development of ultrasonics for the removal of supra and sub-gingival calculus deposits has proven to be an aid in periodontal therapy as well as routine prophylaxis. The course will encompass the principles of ultrasonics and the tissue reaction to these instruments.

For further information please write to Postgraduate Courses, School of Dentistry, University of Pennsylvania, 4001 Spruce Street, Philadelphia 4, Pa.

Subgingival Root Planing: A Comparison Using Files, Hoes and Curettes

by JERRY E. BARNES,* AND ERWIN M. SCHAFFER, D.D.S., M.S.D.,**
Minneapolis, Minnesota

ROOT PLANING is the common denomination to all periodontal pocket eradication whether it is gingivectomy, new attachment (reattachment), or shrinkage. Although the literature is voluminous on the many types of instruments employed in root curettage, there are very few reports comparing the effectiveness of the various types of instruments. It appears that a comparison investigation of the basic instruments would be helpful to determine the type of instrument most suitable for training undergraduate students in root curettage. The objective of root curettage is to remove all calculus leaving a smooth, hard surface. Most teachers and clinicians agree that routine root planing is necessary to fulfill these objectives. What type of periodontal instrument (curette, file or hoe) is best for an undergraduate to remove all of the calculus and to obtain the smoothest root surface? In order to answer this question, the following clinical study was undertaken.

METHODS

In this survey, three basic instruments were employed 1) curettes, 2) files, and 3) hoes. A total of ninety teeth were planed, thirty with each type of instrument. These teeth were to be extracted for prosthetic and restorative reasons. Before extraction, measurements of the gingival sulci depths were made and recorded. Their depths varied from 3 to 7 mm. This was followed by subgingival root planing until the student operator felt that the root surface was free of calculus, smooth and hard. This was determined by the sense of touch using a fine explorer. The teeth were extracted immediately and placed in 10% neutral formalin.

The instruments were used in sequence, such that tooth #1 was planed by curettes only, #2 by files only, #3 by hoes only, #4 by curettes and so on. This procedure of curette, file, hoe, curette, file, hoe was continued until ninety teeth were obtained. The instruments were sharpened before planing each tooth and during planing if they became dull.

Before extraction each tooth was marked for identification. This was recorded along with the annotation of the tooth, the instrument used and the gingival sulci depths. To avoid prejudices there was no attempt to gauge efficiency or smoothness until the full complement of ninety teeth was obtained.

After the full complement of teeth was obtained, they were observed both macroscopically and microscopically, using a dissecting microscope. The teeth were picked at random and were graded blindly for smoothness and efficiency. These gradings are explained below. When recording the gradings, the tooth was known only by number to avoid any favoritism to any one type of instrument. When the entire grading was completed and recorded, the number was replaced by the name of the instrument used on that particular tooth.

Smoothness Calculation: Each tooth was given a value of one, two or three. The value of one was given to a relatively rough surfaced tooth, two for moderately smooth, and three to a tooth planed smooth.

Efficiency Calculation: The root surfaces were divided into eight longitudinal surfaces: mesial, distal, buccal, lingual, mesio-lingual, mesio-buccal, disto-lingual, and

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disto-buccal. This was done to determine (1) the number of pieces of calculus remaining per surface and (2) the surfaces on which calculus remained. Each surface of each tooth was examined and a grade of zero, one or two was given each surface—if zero, one or two pieces of calculus remained respectively.

RESULTS

When obtaining results for both smoothness and efficiency, the teeth were separated into anteriors and posteriors. This was used as an aid to determine if a particular instrument was more effective in any certain group of teeth. One tooth was fractured in extraction and was not included.

Smoothness: Table I shows the number of anterior and posterior teeth planed by curettes, files, and hoes.

TABLE I*

	Number of Teeth	
	Anterior	*Posterior*
Curette	12	15
File	15	14
Hoe	13	12

Table II summarizes the smoothness obtained with the various instruments along with the *total* number of points possible for each group and the *actual* number of points received by that group.

TABLE II

Smoothness of Root Surfaces

	Anterior Teeth				
	Three's	*Two's*	*One's*	*Maximum Possible Pts.*	*Actual Pts.*
Curettes	12	0	0	36	36
Files	0	5	10	45	20
Hoes	0	7	6	39	20
	Posterior Teeth				
Curettes	10	5	0	45	40
Files	1	7	6	42	23
Hoes	2	6	4	36	22

*There were 8 teeth on which smoothness determination was impossible because the subgingival areas were mainly on enamel.

Example: On anterior teeth, 15 were planed by files, such that the total number of points possible is 3 (the highest number of points possible per tooth) × 15 (the number of anterior teeth planed by files) or 45 points, but the actual number of points acquired was 20. The ratio then becomes 20 out of 45. This value multiplied by 100 gives a percentage value of, in this case, $20/45 \times 100 = 44\%$.

Table III gives the results of the smoothness in percentage points.

TABLE III

Percentage Smoothness

	Anterior Teeth	*Posterior Teeth*	*Avg.*
Curettes	100%	89%	94%
Files	44%	55%	49%
Hoes	51%	61%	56%

From these values it can be seen that curettes create the smoothest root surfaces on both anterior and posterior teeth (Fig. 1). Hoes and files produce rougher surfaces but their degrees are relatively close (Fig. 2, 3).

Efficiency: The number of teeth planed by each instrument for efficiency is recorded in Table IV.

TABLE IV

	Number of Teeth	
	Anterior	*Posterior*
Curette	14	16
File	16	15
Hoe	15	13

The results of efficiency appear in Table V and Table VI.

TABLE V

Efficiency in Removing Calculus

	Anteriors			
	Zero's	*One's*	*Two's*	*Total No. of Surfaces*
Curette	106	6	0	112
File	112	14	2	128
Hoe	110	10	0	120
	Posteriors			
Curette	122	5	1	128
File	108	11	1	120
Hoe	101	3	0	104

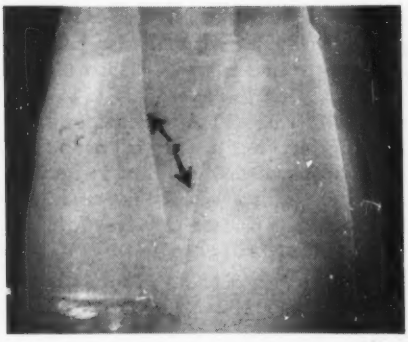

Fig. 1. Root planed with a curette. Fissures (F) from other causes than the instrument are present but the root is not scratched.

Fig. 2. Root planed with a hoe. Fissures (F) from causes other than the instrument are present and so are scratches (S).

Example: The *total surface* figure is arrived at by multiplying the number of teeth planed with a respective instrument, by eight (the total number of surfaces per tooth). The *percent efficiency* is arrived at by dividing the number of surfaces with zero calculus by the total surfaces and multiplying this by 100. For example: Using curettes on anterior teeth, there were 106 surfaces with zero calculus. This figure divided by 112 (the total number of surfaces) and multiplied by 100 equals percent efficiency. ($106/112 \times 100 = 94.6\%$ efficiency).

TABLE VI

Percentage Efficiency

	Anterior	*Posterior*	*Average*
Curette	94.6	95.3	95.0
File	87.5	90.0	88.7
Hoe	91.6	97.1	94.2

In this study the curettes were most efficient in the anterior region, whereas the hoes were most efficient in the posterior region. However, averaging the percent efficiency in the anteriors and the posteriors, the hoes and curettes are less than one percentage point apart.

TABLE VII

Calculus Particles and Location

Posteriors	*Bu*	*MBu*	*M*	*MLi*	*Li*	*DLi*	*D*	*DBu*	*Totals*
Curettes	1	0	3	0	2	0	3	0	9
Files	3	1	3	1	1	1	4	0	14
Hoes	0	0	1	1	0	0	0	0	2
Sub Total	4	1	7	2	3	1	7	0	25

Calculus Particles and Location

Anteriors	*La*	*MLa*	*M*	*MLi*	*Li*	*DLi*	*D*	*DLa*	*Totals*
Curettes	0	0	1	1	1	1	2	0	6
Files	1	0	4	1	1	1	6	1	15
Hoes	1	0	2	1	0	3	2	0	9
Sub Total	2	0	7	3	2	5	10	1	
Gr. Total	6	1	14	5	5	6	17	1	

Fig. 3. Root planed with a hoe. Fissures (F) not produced by the instrument are present and so are scratches (S).

The most calculus remained on the mesial and distal surfaces. The least cal-

culus remained on the line angles mesial and distal to the labial and buccal surfaces.

In some instances, the calculus was planed smooth along with the adjacent tooth surfaces. Holding the tooth in one's fingers and running an explorer over the calculus (smooth) and adjacent smooth tooth surface, the calculus produced a different sound from the adjacent tooth surface.

SUMMARY

Prior to extraction, ninety teeth were planed subgingivally; thirty with hoes, thirty with files, and thirty with curettes.

The curettes produced the smoothest surfaces and the files the roughest surfaces.

The curettes and hoes were the most efficient in removing calculus and the files the least efficient.

When calculus remained after subgingival planing, it was found most frequently on either the mesial or distal surface. The surfaces most frequently devoid of calculus were the line angles mesial and distal to the labial and buccal surfaces.

Although calculus was sometimes planed smooth to the sense of touch, it produced a different sound with the explorer than the adjacent smooth tooth surface.

AMERICAN ACADEMY OF DENTAL MEDICINE

Analysis of the dental patient will feature the mid-winter meeting of the American Academy of Dental Medicine, to be held at the Sheraton-Atlantic Hotel, New York City, Sunday, December 4, it has been announced by Dr. Stephen Nachbar, general chairman.

The business meeting at 10:00 A.M. will be followed by a luncheon and general session to extend from 12 noon to 5:00 P.M.

The topic of scientific discussion will be "The Patient." It will be covered by an anesthetist and a periodontist with special emphasis on analysis of the patient from the physical and psychological standpoints, including such factors as patient tolerance to treatment, systemic conditions influencing treatment, and attitude of the patient.

All members of the Academy and other interested dentists and physicians are cordially invited to attend. For luncheon reservations and copies of program, please address Dr. Nachbar at 30 Central Park South, New York 19, N. Y.

Intracellular Calcification by Oral Filamentous Microorganisms

by J. ENNEVER,* *Cincinnati, Ohio*

THIS investigation was undertaken in order to test the hypothesis that within filamentous microorganisms obtained from dental plaque intracellular calcium salts can be converted to an insoluble form, *in vitro*. If the phenomenon could occur, such microorganisms might serve as a tool for the study of mineralizing systems.

In 1925 Bulleid obtained a mineral precipitating factor from cultures of a filamentous microorganism by macerating or by lysing the cells. He demonstrated the activity by precipitating calcium phosphate from a calcium-supplemented nutrient broth. In a series of well planned experiments, he established that ". . . the precipitating action of the Leptothrix (sic) is due to some property inherent in the actual organism . . .".[1] With Bulleid's findings as a basis, it seemed reasonable to suspect that these microorganisms might be capable of intracellular calcification.

MATERIALS AND METHODS

Organisms comparable in morphologic and biochemical characteristics to those described by Bulleid were isolated from dental plaque.[2] They were transferred to a brain-heart infusion broth (Difco) in which 25 per cent of the liquid portion consisted of a calcifying solution the same as that reported by Wasserman, Mandel and Levy.[3] The final level of added calcium was 1 mg. per cent; the value for phosphorus was 3 mg. per cent. Aerobic incubations were run at 37°C for periods ranging up to 20 days.

The cells were harvested on Millipore filter pads (0.45u porosity). Deionized water, prepared by passing distilled water through a column of Amberlite MB-1, was used for washing. The cells were washed for a minimum of 6 hours. Slides were made as for routine bacteriologic examination except that deionized water served as the diluent and platinum loops were used for making the smears.

Two procedures adapted from standard histochemical techniques, the von Kossa silver substitution and the alizarin red S dye lake reaction, were used for detecting intracellular mineral.

For the von Kossa, the fixed slides were washed for 30 minutes in deionized water and then immersed in 1 per cent silver nitrate for 2 minutes. This was followed by a second 30-minute wash. Developing was done in 1 per cent hydroquinone for 2 minutes and, after a third wash, the smears were counterstained with Safranin 0.

Fig. 1. Microorganisms stained by modified von Kossa technique. X 970

*The Procter and Gamble Company, Cincinnati, Ohio.

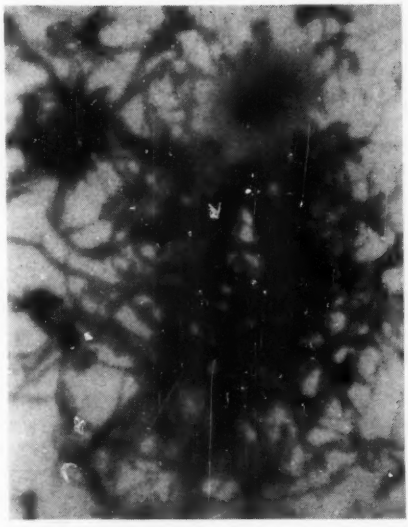

Fig. 2. Microorganisms stained with alizarin red S. X 970

The alizarin red S used was a 1 per cent solution adjusted to pH 4.2 with 3 M ammonium hydroxide. The smears were washed in several changes of water and, while still moist, were placed over concentrated hydrochloric acid for 2 minutes. The slides were then flooded with the alizarin dye for 5 minutes. This was followed by a 20-second wash with a 0.25 per cent aqueous solution of fast green FCF for counterstaining. A final wash was with absolute alcohol. After drying, the slides were placed in ammonia vapor to intensify the color.

Smears that had been incinerated at 680°C for 30 minutes were examined by dark field for residual ash. Untreated wet mounts were examined with crossed polaroids for evidence of intracellular crystalline material.

Cells recovered from the filter pads after the washing procedure were subjected to a 16-hour continuous extraction with ethylenediamine. The residue remaining was examined by X-ray diffraction using a powder camera film technique with a General Electric XRD-1 diffraction unit. The samples were exposed to nickel filtered copper radiation generated at 45 KV, 20 milliampere anode current for 5 hours. Cells not treated for removal of their organic components were examined in a similar manner.

RESULTS

The organisms gave a strongly positive response to the von Kossa test after 5 days. Figure 1 represents a typical finding. Results at shorter growth periods were usually negative. Cells from von Kossa positive cultures routinely were positive with alizarin red S as illustrated in figure 2. An incinerated specimen examined by dark field is seen in figure 3; there was an abundant ash. An example of a wet mount specimen between crossed polaroids is reproduced in figure 4. The indication for intracellular crystallinity is apparent. A diffraction pattern obtained after ethylenediamine extraction

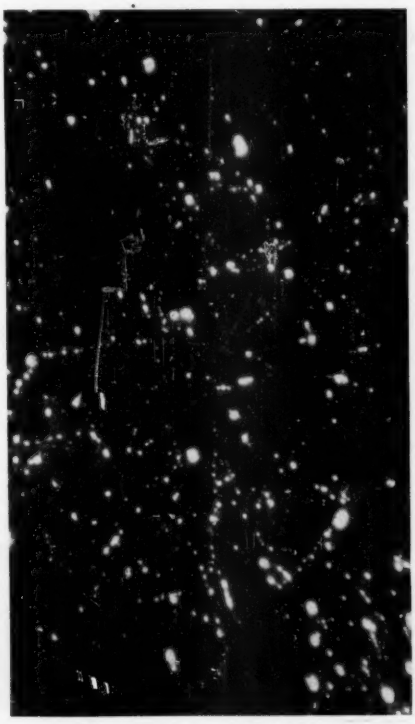

Fig. 3. Ash as seen in darkfield. X 2000

Fig. 4. Wet mount viewed with crossed polaroids. X 1400

is shown in figure 5. For comparison, a pattern for a known calcium hydroxyapatite is included in the illustration. The two patterns are essentially identical. Cells not extracted with ethylenediamine failed to give an interpretable diffraction pattern.

DISCUSSION

The presence of inorganic crystals in certain species of soil fungi, sulfur bacteria and other autotrophic microorganisms has long been known.[4] For the most part the minerals found are calcium carbonate and oxalate. Recently, Pautard demonstrated the presence of apatite crystals associated with the flagellae of 3 unicellular algae after they had grown in a medium containing tap water. In summarizing his findings, Pautard stated, ". . . in much lower organisms than has hitherto been suspected there may be a collagen precursor and an inherent power . . . of forming bone-type hydroxyapatite by processes analogous to those found in higher animals."[5] The results of this study are a substantiation, in part, of this thought. We have shown intracellular mineralization in relatively simple heterotrophic microorganisms. The factors related to the process, however, remain to be clarified.

Taken individually, no one of the separate segments of this investigation is sufficient. If they are considered collectively, however, we can state with a high degree of confidence that the hypothesis was correct. Cetain filamentous microorganisms obtained from plaque can convert intracellular calcium salts to an insoluble form, *in vitro*. Further, the intracellular accretion is calcium hydroxyapatite. Work is now in progress to determine the nature of the factor or factors responsible for the initial seeding of the intracellular calcification. By so doing we shall be able to assess more completely the utility of these cells as means for studying mineralizing systems.

We have purposely avoided applying names to the filamentous microorganisms used in the investigation. This is an area of compounded confusion. Only after more work such as that reported by Richardson and Schmidt[6] will the proper terms be evolved.

It is very improbable that intracellular mineralization by oral microorganisms is a quality unique to those which we have studied. A preliminary look at other bacte-

Fig. 5. Contact print of X-ray diffraction patterns. Top strip is from calcified cells; bottom strip is a known calcium hydroxyapatite.

rial forms indicates that several, given the proper environment, can mineralize. An exploration of this field is indicated.

SUMMARY

Filamentous microorganisms, isolated from dental plaque, were grown in brain-heart infusion (Difco) which contained added mineral salts. By the application of histochemical and physical techniques, we have demonstrated that these microorganisms acquired intracellular, insoluble mineral. X-ray diffraction patterns indicate the crystal species was that of calcium hydroxyapatite.

ACKNOWLEDGEMENTS

The author wishes to express his thanks to W. E. Snyder for the skilled technical assistance he provided. The X-ray diffractions were done by R. H. Lindahl and A. J. Mabis at our Miami Valley Laboratories.

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TUFTS UNIVERSITY SCHOOL OF DENTAL MEDICINE

DPG 602—CLINICAL ADJUSTMENT OF THE OCCLUSION—Wednesday, Thursday and Friday, May 3, 4 and 5, 1961.

Tuition $125.00. Class limited.

Doctor Bernard Jankelson, Clinical Associate and Lecturer, University of Washington, School of Dentistry.

The first day will be devoted to clarification of the physiology of the Stomatognathic area, particularly as it pertains to the occlusion of the teeth. It will be shown that as a result of this information, our concepts of the basic nature of the dentition and of occlusion must be considerably modified.

The remainder of the course will demonstrate the clinical adjustment of a series of cases by means of television projection. The clinical diagnosis and treatment will be done directly in the mouth. A sufficient number of cases will be done to cover the various conditions encountered in practice.

For information write: Director of Division of Graduate and Postgraduate Studies, School of Dental Medicine, Tufts University, 136 Harrison Avenue, Boston 11, Massachusetts.

Triamcinolone Acetonide: Oral Mucous Membrane Toxicity Studies in the Normal Rat

by EDMUND APPLEBAUM, D.D.S., ITALO FRATTA, D.V.M., AUSTIN H. KUTSCHER, D.D.S., AND EDWARD V. ZEGARELLI, D.D.S., M.S., *New York, N. Y.*

TRIAMCINOLONE acetonide (Kenalog),[1-4] a new synthetic corticosteroid, has been introduced to the professions for topical use in the treatment of dermal and oral mucous mebrane lesions. Although minimal amounts of the corticosteroid are absorbed and available for systemic action following application to the skin, that which is applied to the oral mucous membranes in the treatment of acute and chronic lesions is not only active locally but also ultimately is available for systemic activity as the result of absorption at the site of application or following ingestion.

This report is concerned with the results of a study designed to ascertain the local effects of continued (10-day) oral application of triamcinolone acetonide in rats as determined by histological examination of these tissues.

METHODS

Twenty young, male, 200 gram Sherman rats were divided equally into two groups:

Group I was composed of 10 rats. Each animal was treated with the topical application of 20 mg. of a 0.1% concentration of triamcinolone acetonide (in an adhesive vehicle,[5] Orabase) to the oral mucous membranes three times daily. The specific areas so treated were: the mucobuccal fold, gingival, and lower lip areas which directly overlie the lower incisor teeth. Thus, each animal received a total daily dosage of 60 mg. of 0.1% triamcinolone acetonide in Orabase or a total of 0.06 mg. of triamcinolone acetonide per animal or 0.3 mg./kg. per day. This animal dosage may be compared with the maximum anticipated human dosage of 1.0 mg./day for a 70 kg. person or 0.014 mg./kg. of body weight. Therapy was continued for a period of 10 days with an interruption of one day (Sunday) between the 6th and 7th days.

Group II was composed of 10 rats each of which was treated in an identical fashion as those above except that the placebo adhesive vehicle* (Orabase) which was applied to the test site did *not* contain the active ingredient, triamcinolone acetonide.

All animals were fed ad libitum on Hemlock Hollow rat diet. All medications were coded before being administered to the animals, thus insuring a "blind" study throughout.

Animals were sacrificed at the conclusion of 10 days of treatment following which their heads were placed in 10% formalin for at least two weeks. Tissue specimens were obtained from the mucobuccal fold, gingival and lower lip areas directly overlying the lower incisor teeth and tongue of each animal for histological study. All tissues were stained with hematoxylin and eosin and remained "coded" throughout the period of histological study.

RESULTS

Gross observations for local oral evidences of toxicity resulting from the administration of triamcinolone acetonide were entirely negative. Histological studies of the soft tissues of the mouth did not reveal significant changes in the triamcinolone acetonide treated rats, Group I, when compared with the oral tissues of the placebo treated control group, Group II.

Department of Anatomy, College of Physicians and Surgeons, Columbia University, New York, New York, and Division of Stomatology, School of Dental and Oral Surgery, Columbia University, New York, New York.

*The ingredients of the adhesive vehicle (Orabase) utilized in both groups include gelatin, pectin, and carboxymethylcellulose in a mineral oil-polyethylene base.

DISCUSSION

Although deleterious histological changes in the oral soft tissues of the treated rats were not apparent, these findings cannot be construed as being entirely indicative of negative findings for the body as a whole. Nor can these observations be interpreted as evidence that there must have been an absence of any clinical findings. Extreme care must also be taken in the projection of these data in rats to the human species (since differences in terms of dose response in particular and individual tissue responses in general are often of great importance).

The dosages of corticosteroids utilized in this study were calculated to take into account the inherent ability of the rat to adjust in general to larger doses of drugs without evidencing toxic effects when compared with the human—the dosage factor usually applied being of the order of 10 to 1. An additional increment was added as a further safety factor.

The particular sites of application utilized were specifically chosen since it appears that the rat is less able to dislodge easily a tenaciously adherent material such as Orabase from these regions, owing perhaps to the hindrance presented by the incisor teeth which block the movements of the tongue into and about these areas. However, the exact period of time during which the applied material remained in place is not known. The above is admittedly somewhat in contrast to the situation in the human patient—who makes a deliberate effort to keep the medication in place.

SUMMARY

Controlled subacute toxicity studies concerned with the effects of a new topical corticosteroid, triamcinolone acetonide, on normal oral tissues were carried out over a 10 day period of observation in 10 rats receiving 0.1% triamcinolone acetonide in an adhesive vehicle and in 10 rats who remained placebo treated controls. Histological studies of the soft tissues of the mouth did not reveal significant changes in the corticosteroid treated rats when compared with the tissues of the placebo treated control group.

630 West 168th Street,
New York 32, New York

The authors express their appreciation to Mrs. Tanya Genningson, Mrs. Helene W. Kutscher, and Mrs. Aldonna Skislak for their assistance in this study.

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The Problem of Reattachment*

by FRANK E. BEUBE, D.D.S.,** *New York, N. Y.*

IT is quite apparent to all dentists that reattachment means the regeneration of bone, periodontal membrane, and cementum adjoining the old cementum or dentin surface of a root in an area where a periodontal pocket has existed and thus has been eliminated through tissue healing in response to periodontal therapy. Translated in the writer's concept, the laying down of the above mentioned three tissues is tissue repair of a wound (periodontal in this instance) after an injury has been treated.

What is the periodontal wound? It is the periodontal pocket, which is usually a chronic inflammatory type consisting of a fistulous tract which opens into the oral cavity in the vicinity of the gingival margin and enamel. One inner wall of the wound consists of soft connective tissue which is ulcerated, and the other is the hard cemental surface which is believed to be macerated. These are not unusual pathologic findings for a wound. Even the fact that the cementum is the hard tissue wall of the wound does not make it unique. Ulcerated wounds have occurred where the surface of bone is macerated and the adjoining soft tissue wall is ulcerated, and there is a fistulous tract leading to the surface of the skin. A fractured shin bone whose healing has been aborted is a good example. Since cementum is a form of bone, the analogy is an appropriate one.

REPAIR OF TISSUE AFTER INJURY

Anderson has stated that "repair follows *every* injury, whether due to infection, burning, trauma, or other agent." He further comments that the "repair processes involved are similar after injuries of every kind, e.g., healing of ulcers, repair of tuberculous cavities, of abscesses in liver or kidney, or after trauma to deeper parts by missiles."[1]

If the reader tentatively accepts the viewpoint that in the treatment of the periodontal pocket we are dealing with a type of wound whose causes are calcareous deposits, bacterial and other local irritational factors, then it must be concluded that this periodontal wound has a potentiality for healing like any other wound in the body. This conclusion is justifiable even if the periodontal pocket developed because of systemic disease. However, the evidence that pocket formation might be due to systemic diseases is scanty.

A soft connective tissue wound heals by the regeneration of only three tissues. These are blood vessels, fibrous tissue and epithelium. The processes that produce them are endothelial proliferation, fibroplasia and epithelialization. An abundant new growth of blood vessels is essential for regeneration of the other two tissues and precedes slightly.[2] When a wound is exposed to the air a protective crust forms during the healing. When drying of wound is not possible and the coagulated blood cannot form a crust, such as in periodontal pockets, then healing occurs by cell migration.

THE HEALING OF BONE FRACTURES

To understand reattachment, or periodontal wound healing, it is essential to know how bone fractures heal. The following is summarized from McLean's and Urist's studies:—[3] "as in wound healing in every other part of the body, fracture healing begins with the clotting of the extravasated blood." Within 24 hours, on all surfaces, the organization of the blood clot begins. Within a few days fibrin is replaced by granulation tissue. "The torn ends of periosteum, endosteum and bone marrow adjoining the fracture line, supply cells of

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*Originally published in Spanish as part of a symposium on Reattachment in the Revista de la Asosiacion Odontologica Argentina, Volume 47, No. 6, June 1959.

**Professor and Director Section of Periodontology, Columbia University, School of Dental & Oral Surgery.

histogenic origin; these proliferate and differentiate into fibrous connective tissue, fibrocartilage, and hyaline cartilage." Inflammatory cells, such as monocytes, have contributed to the process. At this stage, other than the appearance of cartilage, "the healing process closely resembles that of the repair of any tissue following an injury." An abundant new growth of blood vessels develops, which "originate at least in part from differentiation of perivascular connective tissue cells; these are mesenchymal cells which persist in the adult organism." The fracture unites by a cantilevering out of new bone from the fractured ends of bone to form an arch of new bone over the fracture gap.

STUDY OF WOUND HEALING IN BONE MARROW OF RABBITS AFTER IMPLANTATION OF HUMAN DENTIN FRAGMENTS

It is the writer's belief that the healing of the periodontal wound over the cementum or dentin surfaces is similar, if not identical, to wound repair elsewhere in the body, and in particular to that of a bone fracture. The writer also contends that dentin has a capacity for aiding in some way, or is receptive to the deposition of calcified tissue (new bone or cementum) on its surface. It is further postulated that the root cementum or dentin need not be in the vicinity of the periodontal membrane or alveolar bone for this calcification to occur. To establish proof of this hypothesis the following experiment was performed on rabbits:[4]

EXPERIMENTAL PROCEDURE

Human teeth, which had been extracted because of advanced breakdown of the periodontal structures, were immersed in a solution of Zephrin Chloride shortly after extraction. It was presumed that this would destroy any bacteria on the teeth, and prevent secondary bacterial contamination. Segments of roots from several teeth were fractured off, and with a sandpaper disc the cementum was removed from the dentin. No attempt was made to maintain surgical cleanliness during the removal of the cementum. These fragments of root dentin, which were approximately three by five millimeters were then returned to bottles containing the Zephrin Chloride and retained in this solution from one day to a few weeks and up to the time of operation. The next step in the experiment was to implant a dentin fragment in a femur of a rabbit. Under anaesthesis with Sodium Nembutal (Abbott), the hair was shaved off the leg and an incision of about two inches was made in the skin and fascia. By means of blunt dissection the muscle bundles were separated and the femur bone exposed. With a mallet and chisel, bone was removed and a window of approximately six by six millimeters was made, exposing the bone marrow. A dentin fragment was selected and forcibly inserted into the bone marrow so that it would completely encase the dentin. The muscle bundles were returned to position and the fascia and skin wounds were closed with interrupted sutures. Eight dentin fragments were imbedded in eight femurs. The animals were sacrificed at three, five and six weeks post-

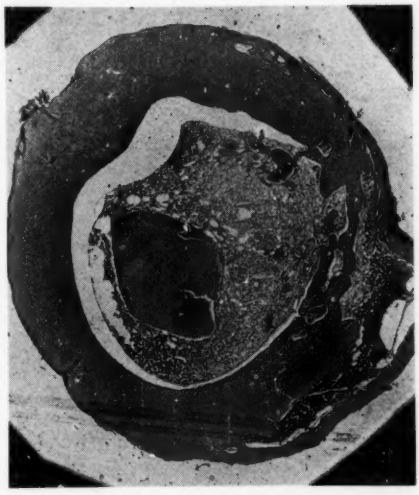

Fig. 1. Human dentin implant in rabbit bone marrow. Low power view of cross section through rabbit femur. At the extreme right, the opening in the bony wall is being closed by deposition of new bone. The dentin implant which can be seen in the marrow and to the left of centre, has its surface covered with a thin dark halo. This is the new calcified tissue (bone or cementum). See high power view in Figures 2 & 3.

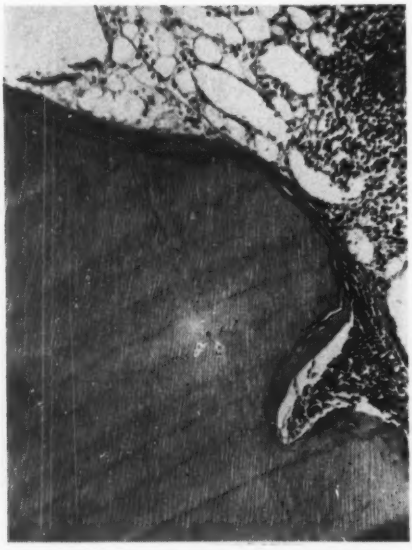

Fig. 2. Human dentin implant in rabbit bone marrow. High power view showing the calcified cellular tissue well adapted to the irregular dentin surface. It has the appearance of cementum or bone. Note slight separation between new calcified tissue and dentin. This is probably due to fixing and preparation of specimen.

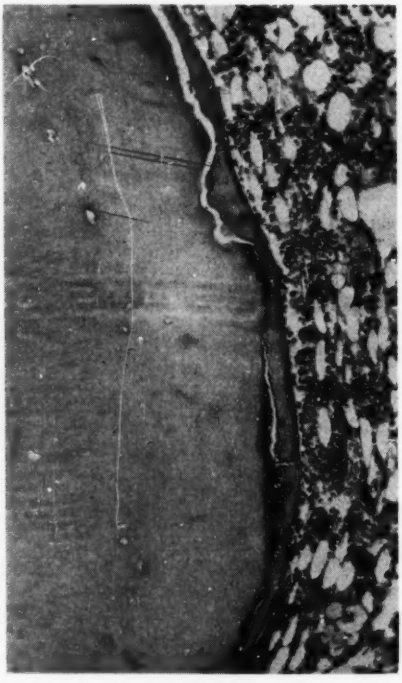

Fig. 3. Human dentin implant in rabbit bone marrow. High power view showing the calcified cellular tissue well adapted to the irregular dentin surface. It has the appearance of cementum or bone. Note slight separation between new calcified tissue and dentin. This is probably due to fixing and preparation of specimen.

operatively and the femurs were removed, fixed in Bouin solution, decalcified and prepared for histologic study. The specimens were cut in cross section through the operated field.

RESULTS

The openings in the bony walls of the femurs were closed by the deposition of new bone. Each dentin fragment had its surface completely covered with calcified tissue. This tissue was cellular, well adapted to the irregular dentin surface, and had the appearance of cementum or bone. The cementum-like tissue occurred on all dentin fragments (Figs. 1, 2, 3).

DISCUSSION

The implantation of human dentin root fragments into the bone marrow of rabbits' femurs, and in absence of any periodontal membrane or alveolar bone, resulted in a repair which simulates one aspect of periodontal wound healing (reattachment); namely, the laying down on dentin surfaces of a calcified tissue which has the appearance of either bone or cementum. It is apparent that dentin has some special inherent quality which induces a calcified repair on its surface. To further establish this fact, and to determine if other substances would result in calcification on their surfaces, human enamel fragments of extracted teeth were also imbedded into the bone marrow of rabbits, as previously described. No bone or cementum-like tissue was deposited (Fig. 4).

It seems reasonable to conclude from the foregoing that the healing of a bone fracture, the laying down of new bone across the openings of the rabbits' femurs and the deposition of bone or cementum on dentin fragments when imbedded in bone marrow, are quite identical.

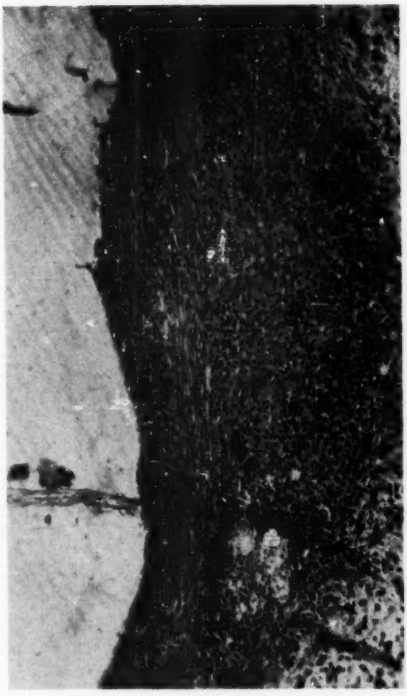

Fig. 4. Human enamel implant in rabbit bone marrow. High power view discloses that no bone or cementum-like tissue was laid down on the enamel surface.

PERIODONTAL WOUND HEALING (REATTACHMENT) IN DOGS

Since tissue healing of a bone fracture, and human dentin implants in rabbit bone marrow are similar, it seems desirable to compare these repairs with that of wound healing of alveolar bone, periodontal membrane and cementum over the roots of dogs' and human teeth.[5]

EXPERIMENTAL PROCEDURE

Twenty-six operations were performed over the roots of dogs' teeth as follows: A semilunar incision was made in the alveolar mucosa overlying the roots of the teeth. The tissue flap was retracted and approximately six by six millimeters of alveolar bone, periodontal membrane, and cementum was removed from the roots of the teeth by means of mallet and chisel. The dentin surface was fully exposed. Blood was then allowed to clot over the denuded dentin and interrupted sutures were used to close the wound. A similar operation was performed in the mucosa over the roots of patients' teeth, which were to be extracted because of uselessness.

RESULTS

Bone formation was ushered in by scattered foci of fibroblasts which gradually extended to involve the whole area. At the same time, large amounts of collagen were noted. Shortly thereafter, thicker collagen fibers were found in certain focal areas, and cuboidal cells formed at the margins of the old buccal bone. Adjacent to the swollen collagen, much of which was quite distant from the denuded dentin, cuboidal cells also appeared together with the deposition of a preossific trabecular matrix. Somewhat later, similar cuboidal cells and cementum matrix formed along the dentinal surface. The cementum matrix appeared identical to the preossific matrix. The vascularity gradually diminished and finally bone, periodontal membrane and cementum were fully formed (Fig. 5).

DISCUSSION

It is apparent that the stages of repair from the time of injury of the periodontal structures overlying dogs' and human roots, to final healing of the wounds, parallel those of a bone fracture as described by McLean and Urist. It is also noted that the denuded dentin surfaces of these dogs and human roots were fully covered with a calcified tissue, rightfully termed cementum. This tissue was identical to the cementum-like structure which was deposited on the human dentin root fragments implanted in rabbits' bone marrow. Since new bone and periodontal membrane were also formed, it can be interpreted that reattachment had taken place.

FACTORS WHICH MIGHT ABORT REATTACHMENT

After periodontal therapy has been fully and adequately prescribed in any given case

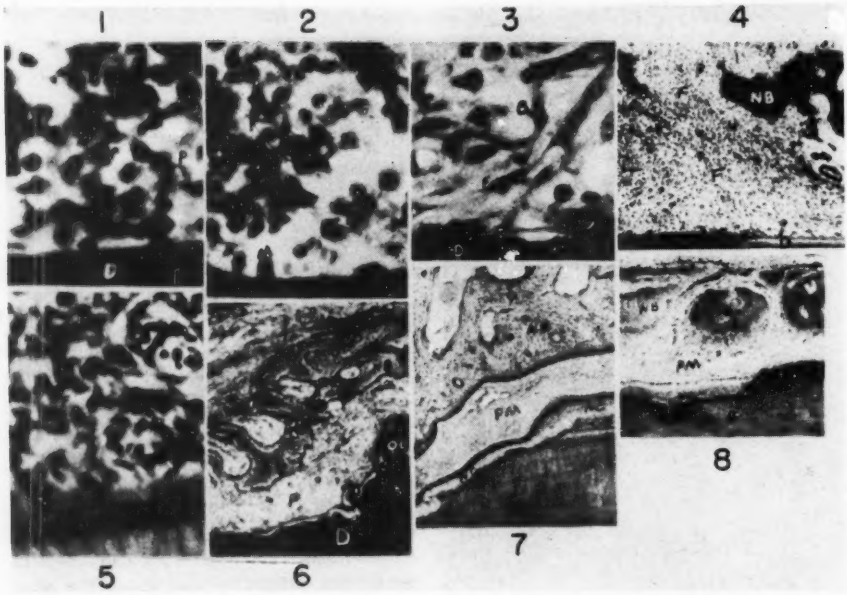

Fig. 5. Stages of repair of periodontal structures in dogs (No. 1 to No. 7) and in humans (No. 8). (1) Day one. Area flooded with polymorphonuclear leucocytes (P); some macrophages in direct contact to dentin surface (D). (2) Days three. Macrophages (M) predominate and a fibrin matrix is being laid down. (3) Days seven. Organizing connective tissue bed, new capillaries (B), and fibroblasts (F). D, dentin. (4) Days seventeen. New bone (N.B.) beginning to be laid down at cut end of old bone. Remainder of gap, between cut ends of old bone and the denuded dentin surface (D), is filled with young connective tissue (F). (5) Days seventeen. Dense young connective tissue bed (F). Collagenous fibers are quite thickened and are in direct contact with the dentin (D), where cementum will be laid down. (6) Days twenty-eight. New bone (N.B.) is filling the gap between the cut ends of old bone. New cementum now covers the irregular dentin (D) surface and cut end of old cementum (O.C.). Between the new bone and cementum, the connective tissue (F) is still present and will become organized into a functioning periodontal membrane. (7) Months twenty. New bone (N.B.) has increased in amount and density. The new cementum (N.C.) is considerably thicker and overlaps the old cementum (O.C.). A well organized periodontal membrane (P.M.) is now functioning between new bone and cementum. (8) Months eight (human). New bone (N.B.) and cementum (N.C.) have been laid down with an intervening periodontal membrane (P.M.). Note the layer of cells which are apparently actively laying down the new cementum which is being deposited on the dentin (D). Note that in all sections, irrespective of the stage of repair, that the new growing tissue is always well adapted to the denuded dentin surface.

for the purpose of eradicating the periodontal wound, healing might still be aborted. If failure to heal occurred, the end result would still be a chronic inflammatory wound: the periodontal pocket. There are several factors which could interfere with the repair.[6] Infected cemental surface or infection contained within the periodontal pocket can prevent the blood clot from properly organizing and becoming attached to the root surface. Regrowth of the pocket epithelium, which can occur in a few hours, may also adversely affect pocket closure. Incomplete removal of the epithelial attachment at the base of the pocket might result in proliferation of epithelium occlusally and laterally. This would abort a connective tissue attachment to the cementum or dentin. The retention of subgingival calculus on root surfaces would also interfere with the natural reparative stages of wound healing. In the event that granulomatous tissue (fibrosis) has developed, and it usually does, within the confines of the pocket and is lying against the root surface, and is not removed by the prescribed periodontal treatment, then it would not be possible to have a calcified tissue deposited on the surface of cementum or dentin. This is due to the fact that calcium salts, necessary for the formation of new cementum, could not penetrate the fibrotic (granulomatous) tissue.[7]

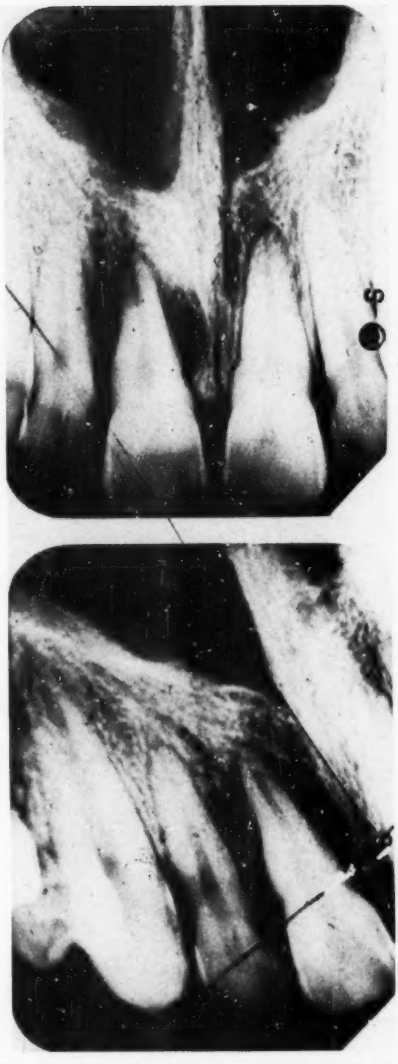

Fig. 6. Two radiographic views of central incisor with extensive circumferential bone loss in a boy aged fourteen. Deep infrabony pockets have formed. Ten millimeters on the distal and eight millimeters on the lingual.

PERIODONTAL TECHNICS WHICH MIGHT INDUCE REATTACHMENT

Although various conditions can obviate the repair of the periodontal structures, as described above, it is the writer's opinion based on the evidence thus far presented in this paper, that reattachment is a possibility. But the following questions which concern all clinicians, must be answered: By what periodontal technics will this tissue repair be achieved? And what will be the frequency of successfully treated cases? Many investigators have attempted to answer these questions by performing experiments on animals and carrying on clinical studies on patients. A few representative authorities and the treatment methods which they used are herewith offered to substantiate the viewpoint that periodontal tissue repair can occur. Morris[8] surgically produced periodontal pockets around patients' maxillary anterior teeth which were recommended for extraction because of prosthetic requirements. He placed a nick on the root, exposing the dentin surface, at the base of the pocket. New cementum formed on the denuded dentin. New bone was also laid down and connective tissue fibers developed parallel to the root, similar to the arrangement of fibers in the normal gingival fiber unit. This experiment can be likened to attempts in reattachment of periodontal pockets, whose irritants have been removed and the inflammatory process having subsided through curettage procedures. Ramfjord[9] created thirteen pockets surgically and placed a groove on the dentin surface of Rhesus monkeys' teeth. Bands were cemented on the teeth to allow epithelialization of the pockets. Subsequent subgingival curettage resulted in reattachment coronal to markings on roots. Root and soft tissue curettage was also successfully used by Carranza[10] to get periodontal tissue repair in patients who had periodontal pockets. There is general agreement amongst clinicians, who have attempted to obtain reattachment, that infrabony pockets, especially—the three-walled type, treated by curettage or flap approach, are the most suitable type which will yield the highest percentage of successful results. Glickman[11] referring to repair of the infrabony pocket has summed it up by stating that: "as the clot undergoes organization, tissue is formed between the tooth surface and the bone.

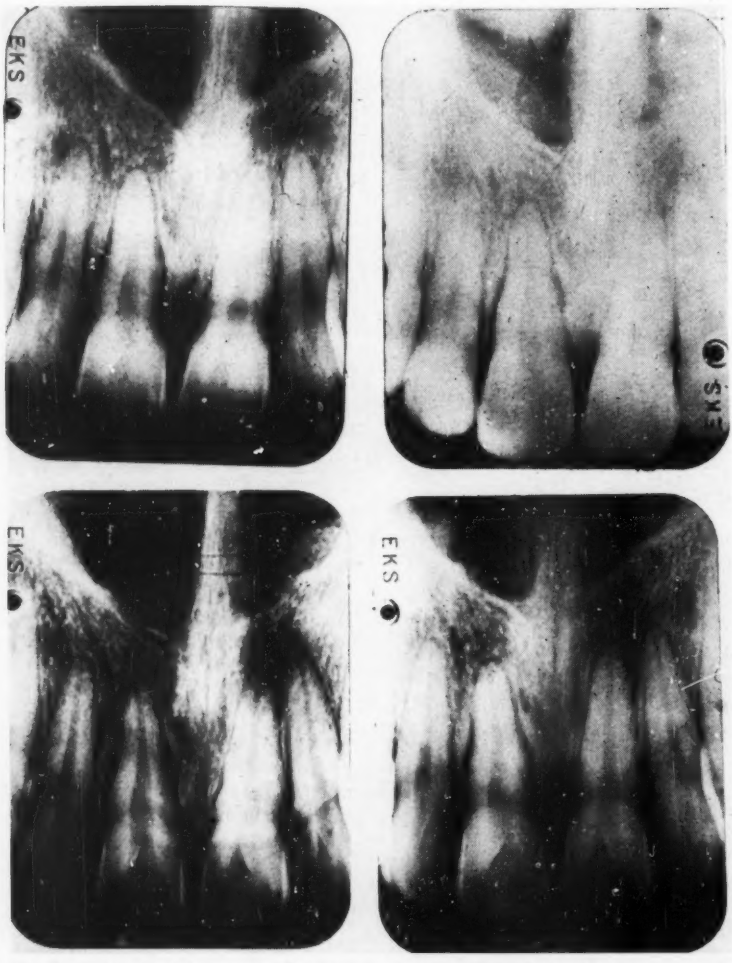

Fig. 7. One and one-half years postoperative of case in Fig. 6. New bone has obviously formed around the tooth. At the distal surface there is a wide space located at the incisal half of the root, between the newly laid down bone and the tooth. The four radiographs were taken on the same day at different time exposures.

With maturation of the granulation tissue, the bone is readily accessible for the deposition of osteoid and the embedding of collagenous fibers. . . . The availability of the bone as a support for embedded periodontal membrane fibers facilitates the extension of the height of periodontal fibers to the denuded tooth surface." Prichard[12] has shown periodontal tissue repair after the treatment of periodontal pockets by curettage, gingivoplasty, and flap approach. Histologic evidence of reattachment through curettement technic, was recorded by Cross[13] and by Schaffer and Zander.[14] Goldman[15] considers that reattachment might occur after gingivectomies have been prescribed. He writes: ". . . in isolated instances the gingival attachment appears coronal to the original attachment point. This may be interpreted as a true reattach-

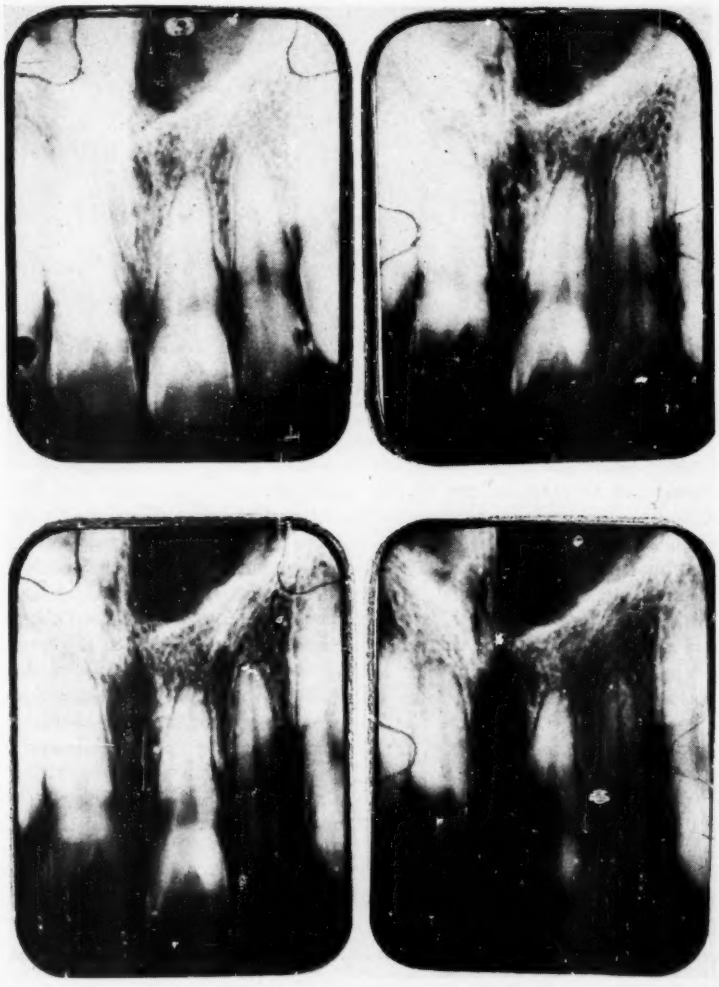

Fig. 8. Three years postoperative of case in Figs. 6 & 7 (The radiographs have been reversed). The space at the distal and incisal half of the root have become narrower due to additional laying down of new bone towards the root. This substantiates the evidence that bone is laid down a little at a time from the old bone in direction of root. The four radiographs were taken on same day at different time exposures.

ment taking place in an area directly above the initial incision." . . . Studies on the regeneration of the supporting structures of the teeth were investigated by Linghorne and O'Connell[16, 17] by using the flap approach and bone chips. They observed that new bone and cementum was laid down, and that new connective tissue fibers were found parallel to the root surface. Hirschfeld,[18] through curettage of root and soft tissue of a large number of periodontal pockets presented radiographic evidence of bone repair around the affected teeth. Sicher[19] has reported that there is a probability that reattachment of the epithelium to the tooth surface can also occur.

These investigators, and others, too many

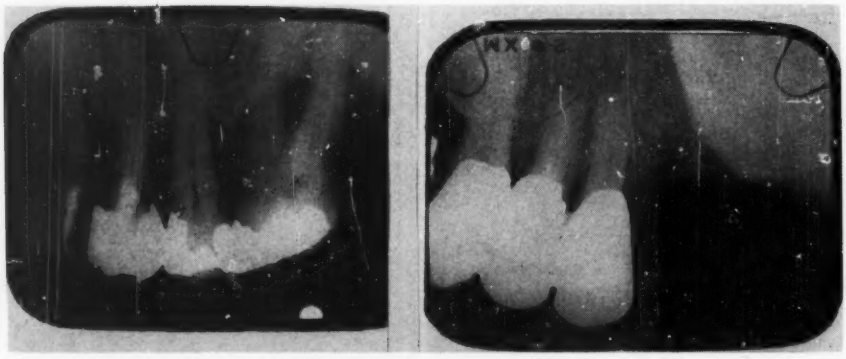

Fig. 9. Preoperative view discloses that one-half the bone around the roots have been destroyed. The molar tooth was hopeless and was extracted. After treating by curettage, gingivectomy and fixed splinting, new bone can be seen in the postoperative radiograph. The incompletely filled root canal of the first bicuspid was untreated. The cast veneer crown now covers most of the root canal filling.

to be included in this report, have clearly demonstrated that the attachment apparatus is repairable by various periodontal technics. In support of their findings, several cases treated by different periodontal methods have been selected by the writer and offered as additional proof that the periodontal wound can become reattached. Figure 6 discloses the radiographic evidence of marked bone destruction around the maxillary right central incisor in a boy aged fourteen. As a result of the bone loss, infrabony periodontal pockets developed on the distal surface (10 millimeters in depth) and lingual surface (8 millimeters in depth). Subsequent to curettage of the root and soft tissues, radiographs were taken at different time intervals. Figure 7 discloses the appearance of the repair approximately one and one-half years postoperative. New osseous tissue has obviously formed around the tooth. Note at the distal there is a wide space located at the incisal half of the root, between the newly laid down bone and the tooth. It is of interest to attempt an interpretation of this finding. It was pointed out earlier in the paper, that a bone fracture unites by the cantilevering of newly formed bone across the fractured gap, extending and starting from the fractured ends of the old bone. The reason for this is clearly described by Ham:[20] "In every instance where bone forms, special bone-building cells, the osteoblasts, must first make their appearance—these cells alone are capable of manufacturing the special organic intercellular substance of bone. Such bone as develops in any site is a result of their progressive activity; it is not the result of tissue transformation. For this reason, large deposits of bone are never formed quickly. Bone always forms a little at a time." This phenomenon apparently took place in this case. The radiograph which is seen in (Fig. 8) was taken three years postoperative. This discloses a reduction of the width of the space between the root and the new bone. This seems to confirm that the laying down of new bone commences at the surfaces of the old bone, therefore simulating the closure of a bone fracture gap. It is now necessary to determine the contents of the space between the root and newly laid down bone, and what tissue growth, if any, occurred on the old cementum and the exposed dentin surfaces. In the experiment on the dogs' and human roots, which were denuded of their bone, periodontal membrane, and cementum, it was consistently observed from the first day of healing to the final regeneration of new bone, cementum, and periodontal membrane, that the denuded dentin surface was fully covered with young connective tissue (Fig. 5). It was also noted, that when new bone was forming, new cementum was simultaneously being de-

Fig. 10. Deep infrabony pockets are noted around the first bicuspid. Extensive bone loss can also be seen between the second bicuspid and molar. The latter tooth was extracted and curettage was prescribed elsewhere. New bone formed on the distal of the second bicuspid, and between the two bicuspids, where a lamina dura was also laid down. (Courtesy of Leonard Hirschfeld, Section of Periodontology, Columbia University, School of Dental and Oral Surgery, New York, New York.)

posited on the root dentin, and that between these two calcified tissues, the developing connective tissue was always present. It therefore seems reasonable to conclude that not only was new bone formed as shown in Figures 7 & 8, but also new cementum had been deposited, although not apparent in the radiographs. Furthermore the space or radiolucent area between root and bone was probably filled with connective tissue and functioning as a periodontal membrane.

Figure 9 discloses the preoperative and postoperative views in a case of advanced periodontal breakdown. This male patient was forty-five years of age when treatment was initiated. Curettage, gingivectomy and fixed splinting were prescribed. Bone formation as part of the tissue repair can be noted. Again it can be surmised that the other structures of the attachment apparatus have been regenerated too.

Curettage played a significant role in the building up of new bone around the maxillary first bicuspid shown in (Fig. 10). The patient was female aged forty-eight. Note also the new lamina dura between the two bicuspids. Deep infrabony pockets had been recorded prior to treatment. The postoperative view of the same case indicates that the maxillary first molar has been extracted. This was necessary because of extensive periodontal destruction, with involvement of the trifurcation and marked mobility. The removal of this tooth aborted the progressive destructive effect which the

Fig. 11. The radiograph on the extreme left was taken immediately postoperative after making a tissue flap and implanting boiled cow-bone powder. The adjoining radiograph is ten months postoperative. Some new bone can be seen. The third radiograph from the left is two years postoperative, showing considerable new bone and an accompanying lamina dura. Fixed splinting has now been done. The fourth view is fifteen years postoperative. The bony tissue repair has been maintained.

Fig. 12. Low power view of the case in Fig. 11, which was treated by flap approach and inserting of boiled cow-bone powder. New cementum was laid down on the old cementum. Transseptal fibers are quite apparent directly above the dense new bone. This can be seen as a lamina dura in Fig. 11. (Reattachment has occurred.)

irritants and pockets engendered, and the periodontal wound was able to heal with resultant bone formation along the distal surface of the second bicuspid. It seems highly improbable that the laying down of the new bone, on the distal of this tooth and similar osseous structure around the first bicuspid, occurred without the accompaniment of the other phases of connective-tissue repair; that is, a new periodontal membrane and new cementum.

The radiographic demonstration of new bone formation in the cases herein recorded, correlated to the findings of other workers and that of the writer's studies on animals, appear to be acceptable proof of reattachment. However, further confirmation can be obtained through histologic examination from biopsy of patients' teeth and periodontal structures which have been affected by periodontal disease, subsequently cured through treatment. The histologic findings of a treated case of periodontal disease was reported in an earlier paper[12] and is summarized as follows: An eight millimeter infrabony pocket on the mesial of a mandibular cuspid, in a male patient aged forty-three was treated by curettage over a period of several months, but periodontal wound healing did not occur. Since curettement failed to achieve periodontal pocket closure it was decided to attempt the use of the flap approach and to implant boiled cow-bone powder. Radiographs (Fig. 11) taken intermittently from the day of operation up to fifteen years postoperative clearly

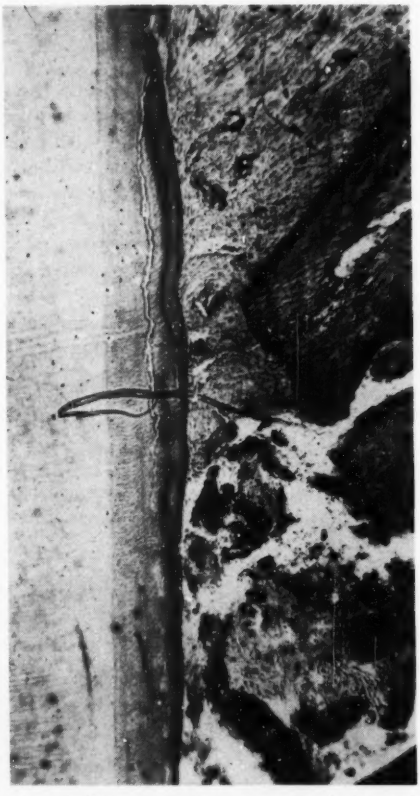

Fig. 13. High power view of the case in Figs. 11 & 12, which was treated by flap approach and insertion of boiled cow-bone powder. The new cementum is clearly outlined and deposited on the old cementum. Note space between old and new cementum. This is probably due to fixing and preparation of specimen. New periodontal fibers and bone have also formed. (Reattachment has occurred.)

demonstrates the consistent laying down of new bone. A dense lamina dura had also formed at the crest of the interdental bone between the affected tooth and adjoining lateral incisor. The presence of the lamina dura is indicative of bone being stimulated by function. In order to function adequately the bone must be connected to the root by periodontal membrane fibers. Goldman[22] has stated it appropriately as follows: "this apposition of cortical bone constituting radiographically the lamina dura is interpreted as a response to function. If this is true, a functioning periodontal membrane must have been reformed to be able to transmit function to the bone." Glickman[23] also reported that there is a direct interrelationship of developing bone and the presence of a periodontal membrane. He wrote: "the maximum height which the bone can attain after treatment is determined by the level at which the periodontal membrane is attached to the root." Evidence that these concepts are correct was established by the biopsy and histologic examination of the periodontal tissues and teeth at the end of the fifteenth postoperative year. The tissue sections revealed that a new periodontal membrane and bone was formed. New cementum has also been laid down on the old cementum. Transseptal periodontal fibers were also present and attached to the new cemental tissue (Figs. 12, 13).

SUMMARY AND CONCLUSION

Reattachment of the supporting structures of the teeth was compared with, and was concluded to be similar to wound healing in the rest of the body, and is particularly analogous to the repair of bone fracture. Justifiable use of this comparison, and proof of this conclusion was shown by the formation of calcified tissue (bone or cementum) on human dentin root fragments after implanting into rabbits' bone marrow. The stages of repair of a bone fracture wound was also found to be identical to those observed in wounded periodontal structures of dogs and humans. Reattachment was shown to be a possibility by examination of the works of others on animals and in clinical studies. Through the use of various periodontal technics it was demonstrated by radiographic findings that bone can be restored in areas where periodontal pockets had been present prior to treatment. The weight of evidence supports the view, that whenever new alveolar bone was deposited, new periodontal membrane and cementum were also formed. Substantiation for this interpretation was presented through biopsy and histologic examination of a treated and successfully healed periodontal pocket overlying the root of a human tooth. It can therefore be concluded from all the foregoing, that reattachment can definitely occur. What is still necessary, is a refinement of our periodontal technics in order to more frequently achieve this type of repair.

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Announcements . . . .

AMERICAN ACADEMY OF PERIODONTOLOGY ANNUAL MEETING

October 13-14-15, 1960

Theme of the Program:

Role of the Tooth in Periodontal Disease

The tentative program for the Annual Meeting of the American Academy of Periodontology, which will be held in the Miramar Hotel in Santa Monica, California, October 13-15, 1960, was published in the July issue of the JOURNAL OF PERIODONTOLOGY (page 254). To that should be added the program for the Research Forum which will be held Saturday afternoon, October 15, from 2 to 5. This program was planned by Drs. Frank M. Wentz, Helmut Zander, and Irving Glickman, Chairman and Moderator.

P.M.

2:00 "Nutritional Studies on Periodontal Disease and Calculus in the Small Laboratory Animal"
Paul N. Baer, D.D.S.
National Institute of Dental Research
Department of Health, Education and Welfare
Bethesda, Maryland

2:15 Discussion

2:20 "Vital Staining of the Periodontal Structures"
Richard E. Stallard, D.D.S.
University of Minnesota
School of Dentistry
Minneapolis, Minnesota

2:35 Discussion

2:40 "A Study of the Early Stages of Repair in an Infra-Bony Type Defect"
Jerome M. Serling, D.D.S.
Boston University
School of Medicine
Boston, Massachusetts

2:55 Discussion

3:00 "Response of the Periodontal Structures Around the Alveolar Crest to Surgical Procedures"
Daniel A. Grant, D.D.S.
University of Southern California
School of Dentistry
Los Angeles, California

3:15 Discussion

3:20 "A Clinical Study of the Effect of Periodontal Therapy in Diabetic Patients"
Charles F. Sumner, III, D.D.S.,
Walter Reed Army Hospital
Walter Reed Army Medical Center
Washington, D.C.

3:35 Discussion

3:40 "Some Observations Regarding Calculus Formation in Humans"
Samuel Turesky, D.M.D.
Tufts University
School of Dental Medicine
Boston, Massachusetts

3:55 Discussion

4:00 "The Microhardness of Dentin and Cementum of Normal Teeth and Teeth with Periodontal Disease"
Clifton A. Rautiola, D.D.S., M.S.
The University of Michigan
School of Dentistry
Ann Arbor, Michigan

4:15 Discussion

4:20 "A Clinical and Histological Study of Healing Following Resection of the Attached Gingiva and Reflection of the Alveolar Mucosa in Monkeys"
D. Walter Cohen, D.D.S.
University of Pennsylvania
Graduate School of Medicine
Philadelphia, Pennsylvania

4:35 Discussion

4:40 "Some Observations on Systemic Influences Upon the Periodontium of the Hamster"
David F. Mitchell, D.D.S.
School of Dentistry
Indiana University
Indianapolis, Indiana

4:55 Discussion

DR. HAROLD RAY

As announced briefly in the July issue of the JOURNAL OF PERIODONTOLOGY (page 253) Dr. Harold Ray of San Francisco, California, died in London on July 7, 1960. No details have yet been learned but it is known that Dr. Ray left the Workshop on the Teaching of Periodontology (Graduate and Postgraduate) on June 25 in excellent spirits and went directly to London. He spent some time in the hospital before his death.

It is hoped that details will be available for publication in the October issue of the Journal.

UNIVERSITY OF WASHINGTON SCHOOL OF DENTISTRY

The University of Washington School of Dentistry Department of Postgraduate Dental Education is presenting a course on Periodontal Prosthesis October 4, 5 and 6, 1960. The course will be presented by Drs. D. Walter Cohen and Morton Amsterdam, both of Philadelphia, Pennsylvania.

Tuition is $150. For further information please write the University of Washington School of Dentistry Department of Postgraduate Dental Education.

Beg Your Pardon . . . .

Inadvertently the following references were omitted from the article entitled "Unusual Deposition of Calculus" by Dr. Bernard S. Moskow of Boston, Massachusetts, which was published in the July issue of the JOURNAL OF PERIODONTOLOGY (page 246):

1. Leung, S. W.: The Uneven Distribution of Calculus in the Mouth. J. Periodont. 22:7-8, 1951.

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Since Dr. Moskow did not refer to these references in his article, the Editor missed them. Sorry!